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CONSUMER PROTECTION AND ENVIRONMENTAL HEALTH SERVICE
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Reports

Radiation Doses to Children's Thyroids from Iodine-131 in Milk

Robert H. Neill and *Paul B. Robinson*[1]

Measurements of iodine-131 in milk taken since 1957 were used to estimate the average cumulative radiation doses to children born and living in selected U.S. cities. The cumulative doses were summed for a cohort (born in a particular year and city) from quarterly doses calculated by varying thyroid weight, uptake factor, and milk consumption, as a function of the age of the child and concentrations of iodine-131 in milk as a function of time and location. Average values of these variables were selected for each quarter.

For a given concentration of iodine-131 in milk, the population receiving the greatest dose are milk-drinking infants of 6 to 11 months of age. Considerable variation was found to exist in cumulative doses for children raised in different cities. Within a particular city, there is a large variation in thyroidal doses for children born in different years.

The largest doses were 1,750 mrem and 1,625 mrem, received by children born in 1957 in St. Louis and Salt Lake City. At the time of the cessation of weapons testing in 1963, the average child of 6 years of age in four of the five U.S. cities where data are available had received man-made cumulative thyroidal doses greater than his cumulative natural dose. Because of the relative absence of iodine-131 in the environment for the past 4 years, the children of today whose cumulative fallout exposure exceed their natural background exposure are those born in 1957 in Cincinnati, Salt Lake City and St. Louis. From the results obtained from these three out of five cities for which data are available, it is apparent that children born in 1957 in Cincinnati, Salt Lake City, and St. Louis, and possibly in some other unmonitored areas of the United States, have cumulative thyroidal doses from iodine-131 following atmospheric weapons tests greater than their cumulative natural background doses, but less than the cumulative dose at an annual dose rate equal to the Radiation Protection Guide (RPG) during the same period.

This report estimates the cumulative thyroidal radiation dose to children born after 1957 from drinking fresh, whole milk containing iodine-131 from atmospheric weapons testing. Although iodine-131 was present in the environment as early as 1945, 1957 was selected for the study origin since it was the earliest year for which iodine-131 in milk was routinely measured.

Children were selected for this study since they are major consumers of fresh milk, their thyroid weights are the smallest, they are generally considered to be the most radiosensitive, and their total exposure history can be defined.

While the best method of estimating thyroidal exposures to various subpopulations is by the measurement of radioiodine in the thyroid, only limited data are available for either *in vivo* or *in vitro* studies (*1-3*). Consequently, an indirect method was used to calculate the iodine-131 dose to an average individual's thyroid via a one-compartment model. To do this, it is necessary to know the amount of iodine-131 ingested, the fraction that reaches the thyroid, and the weight of the thyroid gland (*4*). The first is the product of the concentration of the radionuclide in the milk and the amount of milk consumed. It is assumed that the sole source of iodine–131 intake is fresh milk. Because the biological parameters listed above change rapidly at early ages, the method of calculation considered these parameters as functions of age.

---

[1] Mr. Neill is deputy chief, Office of Criteria and Standards, Bureau of Radiological Health and Mr. Robinson was formerly staff officer, OCS, BRH, and is presently a member of the technical staff at the Bell Telephone Laboratories. Holmdel, N.J.

Age-dependent thyroidal dose estimates using milk data were reported by Lewis as early as 1959 (*5*). In this report, the cumulative dose for an average child in 60 U.S. cities was obtained by a retrospective cohort approach developed by a Division of Radiological Health Committee in 1964.[2] Doses were estimated for each quarter year of a child's life in conjunction with the appropriate milk consumption rate, organ weight, and uptake factor for that particular age and the applicable concentrations of iodine–131 in milk at that time. The calculation was repeated using the appropriate concentration of idoine–131 in milk to be found in the following quarter year, together with the biological parameters associated with a child who is 3 months older. The quarterly doses, including the contribution from the second and third trimester of the gestation period, were then summed to obtain the cumulative dose.

Model

Although more sophisticated multicompartment models have been published in the past (*6–7*), a one-compartment model was selected since it has been used by the Federal Radiation Council (FRC) (*8–11*) and the International Commission on Radiological Protection (ICRP) (*4*).

The following assumptions were made:

(a) the sole source of iodine–131 results from the ingestion of fresh, whole cow's milk. The contribution from other foods was not evaluated due to the absence of routine measurements. Although Eisenbud (*12*) reported the presence of iodine–131 in the thyroid of a nonmilk-drinking individual in New York who consumed yogurt, and Bostrom (*13*) reported iodine–131 in lettuce in Utah following an atmospheric weapons test in Nevada, these foods are not considered to be major foodstuffs for children;

(b) the radioiodine is uniformly distributed in the thyroid;

(c) all beta-particle energy released in the thyroid is absorbed in the thyroid. Assuming a spherical shape for the thyroid, its radius at birth of 7 mm permits most of the energy of the beta particles whose range is 2 mm to be absorbed. This is less true for the fetal thyroid;

(d) the contribution by gamma photons amounts to about 10 percent of the total dose and is included by weighting the energy released per disintegration. Comparison with the Hine and Brownell expression for total dose (*6*) which considers the size of the thyroid for the gamma contribution, shows the dose in this paper to be 4 percent lower at birth and negligibly different at age 10;

(e) the disappearance rate from the thyroid is composed of the radioactive decay and biological elimination;

(f) no adjustments for sex, health, race, economic status, geographical or other epidemiological factors need to be made in the model;

(g) the relative biological effect (RBE) factor is equal to 1;

(h) milk samples obtained from the PHS Pasteurized Milk Network (PMN) and Raw Milk Network (RMN) are representative of the milk consumed at each of the stations;

(i) the uptake of iodine–131 is instantaneous;

(j) the biological half-life is constant and equal to 138 days (*4*). Since the effective half-life is equal to the product of the biological half-life and the physical half-life divided by their sum, a considerable variation in biological half life will not markedly affect the effective half life of 7.6 days for iodine–131 used in the calculation. For example, biological half-lives of 40 days and 300 days shift the effective half life (and calculated doses) by −12 percent and +0.3 percent, respectively.

Derivation of equations

The equation for thyroidal dose due to a continuous intake of P (μCi/day) during a quarter year may be developed as follows:

---

[2] Weiss, E. S., S. P. Abrahams, A. H. Wolff, R. H. Neill, A. Berger, G. Gaffney, and C. E. Nelson. Doses from iodine–131 found in radioactive fallout, unpublished committee report (1964).

For $0 \leq t \leq 90$ days

$$\frac{d(f_tq)}{dt} = P - \lambda(f_tq)$$

Now $f_tq = 0$ at $t = 0$
Therefore,

$$f_tq = \frac{P}{\lambda}(1 - e^{-\lambda t}) \qquad \cdots \quad (1)$$

For $t \geq 90$ days

$$\frac{d(f_tq)}{dt} = -\lambda(f_tq)$$

Now $f_tq = f_tq(90)$ at $t = 90$ days
Therefore,

$$f_tq = \frac{P}{\lambda}(e^{\lambda 90} - 1)e^{-\lambda t} \qquad \cdots \quad (2)$$

where

f_tq = amount of iodine-131 in thyroid at time t(μCi);
λ = effective decay constant (day^{-1});
P = rate of radioiodine intake to thyroid (μCi/day).

now

$$D = \int_0^\infty D_r\,dt \quad \text{and} \quad D_r = \frac{k}{m}(f_tq)$$

where

D = infinite dose from the exposure during a quarter (mrem);
D_r = dose rate (mrem/day);
k = proportionality constant
m = weight of thyroid (g)

The total dose can then be expressed as the sum of both contributions of equations (1) and (2) as

$$D = \frac{kP}{\lambda m}\int_0^{90}(1 - e^{-\lambda t})dt + \frac{kP}{\lambda m}(e^{\lambda 90} - 1)\int_{90}^\infty e^{-\lambda t}dt$$

$$D = \frac{kP}{\lambda m}$$

where $P = 10^{-6}\,M'sf_w$ (μCi/day)

$$k = \left(\frac{10^{-6}\text{ Ci}}{\mu\text{Ci}}\right)\left(\frac{3.7 \times 10^{10}\text{ dis}}{\text{sec-Ci}}\right)\left(\frac{0.22\text{ MeV}}{\text{dis}}\right)$$

$$\times\left(\frac{1.6 \times 10^{-6}\text{ erg}}{\text{MeV}}\right)\left(\frac{10^{-2}\text{ rad-g}}{\text{erg}}\right)\left(\frac{1\text{ rem}}{\text{rad}}\right)$$

$$\times\left(\frac{7.2 \times 10^{4}\text{ sec}}{\text{day}}\right)\left(\frac{90\text{ day}}{\text{quarter}}\right)\left(\frac{10^{3}\text{ mrem}}{\text{rem}}\right)$$

$$= 11.25 \times 10^{3}\,\frac{\text{g-mrem}}{\mu\text{Ci-day}}\left(\frac{90\text{ day}}{\text{quarter}}\right)$$

Substituting the appropriate values, one obtains

$$D = \frac{0.01125M'sf_w}{m}$$

where

D = infinite dose from the exposure during a quarter (mrem)
M′ = concentration of iodine-131 in milk (pCi/liter)
s = consumption of fresh milk (ml/day)
m = weight of thyroid (g)
f_w = fraction of ingested radioiodine reaching the thyroid.

The cumulative thyroidal dose $[D(T, \theta)]$ is the sum of the quarterly doses received by a child. Since the consumption (s), uptake factor (f_w) and mass of the thyroid (m) vary with the age of the child at the beginning of the study (θ, quarter years) and the iodine concentration is a function of the time and location of the exposure, one can write

$$D(T, \theta) = \sum_{t=0}^{T} \frac{0.01125\,M'(t, \theta)s(t, \theta)f_w(t, \theta)}{m(t, \theta)}$$

Since D, M′, s, f_w and m are functions of age, the general form of the functions, $G(t, \theta)$, could have been written as $G(t + \theta)$.

where T = total length of study period (quarter years)
and t = time since study began quarter years).

The products of s, f_w and m^{-1} are shown in table 1. It is of interest to note that the last column identifies 6- to 11-month-old children as the subpopulation that receives the greatest dose for a given iodine-131 concentration in milk although knowledge of possible differential radiosensitivity of the age groups would have to be considered in evaluation of the final radiological health significance of these relative numbers.

6

Table 1. Estimates of average values of milk consumption, thyroid uptake of iodine-131 and thyroid weight for specified age groups

Age group	Milk consumption[a] (ml per day)	Iodine-131 thyroid uptake (fraction)	Thyroid weight (grams)	Consumption × uptake / Thyroid weight
	Average	Average	Average	Average
2nd trimester	[a]1,000	0.002	0.1	20.0
3rd trimester	[a]1,000	.016	.7	22.9
0–2 months	[b]100	.30	1.5	20.0
3–5 months	500	.30	1.8	83.3
6–11 months	700	.30	2.0	105.0
12–23 months	600	.30	2.3	78.3
24–35 months	700	.30	2.9	72.4
36–59 months	800	.30	3.9	61.5
5–9 years	800	.30	5.3	45.3
10–14 years	900	.30	9.6	28.1
15–19 years	1,000	.30	14.2	21.2
20–29 years	500	.30	15.6	9.61
30 years and over	400	.30	17.5	6.86

[a] At fetal ages, consumption figures are for mother.
[b] Average portion of total milk consumption that is received from fresh, whole cow's milk.

Fraction of iodine–131 reaching the thyroid

Uptake fractions by Evans (*14*) for the fetal thyroid are shown in table 1. Since the evidence (*14*) indicates that iodine–131 begins accumulating in the fetal thyroid at the beginning of the second trimester, the cumulative doses included this contribution. After birth, the uptake fraction was assumed to be 0.30 as reported by the Federal Radiation Council (*11*) and ICRP (*4*). Recent unpublished data[3] suggest that uptake fractions after birth are 0.20. While we have chosen to retain the published 0.30 figure in our calculations, the reader is advised that the results may be high by about 50 percent.

Mass of the thyroid gland

Prenatal thyroid weights shown in table 1 were those reported by Evans (*14*). Postnatal values were taken from Kay, et al (*15*). Both are similar to weights reported by Mochizuki (*16*) for thyroids obtained in New York City. For the purpose of the study, the mass of the thyroid was assumed to vary exclusively with age.

Eisenbud (*17*) and Beierwalters (*18*) have each reported fetal to maternal ratios of iodine–131 activity per gram of thyroid of 1.13 and 1.16, respectively. In the former case, the 5-month fetus (representative of the second trimester) and in the latter, full term (representative of the third trimester). Using an uptake fraction of 0.30 and thyroid weight of 15.6 g for the mother, the calculated uptake fractions are 0.0217 g and 0.0223 g, respectively. These compare quite well with those used in the calculations of 0.02 and 0.0228 fraction/g, respectively.

Concentrations of iodine–131 in milk

Monthly measurements of iodine–131 in milk were started in June 1957 at five Raw Milk Network stations (RMN). The network was expanded to 9 stations in August 1958. Weekly measurements of iodine–131 concentrations in pasteurized milk are available from most of the 63 stations comprising the Pasteurized Milk Network (PMN) from 1961 to the present. These data have been published each month in *Radiological Health Data and Reports*. Considering the results of Robinson (*19*), it was assumed that concentrations obtained by the two networks are interchangeable and that they both reflect iodine–131 in milk being consumed in these cities. While the PMN samples are composited to reflect the average milk being consumed in a given city, the RMN is composited somewhat differently.

Corrections were made for the decay of iodine–131 in milk by assuming a 2-day elapsed time between sample collection and consumption. The calculated doses were thus reduced by 17 percent. In rural areas where there may be a time lag of only 1 to 2 days from production to consumption, the calculated estimates could be increased by 30 percent.

Since there are no data on iodine–131 in milk prior to 1961 at 53 cities, the thyroidal estimates for children in those communities do not include any exposures prior to 1961. For example, the calculation of total cumulative dose to a child born in 1957 in Denver, Colo., does not include any exposures prior to 1961.

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[3] Personal communication, Henry N. Wellman, January 24, 1967.

[4] Division of Radiological Health. A pilot study of the average daily intake of milk among small children in a selected area of the United States, unpublished report (December 1962).

Milk consumption

Consumption of fresh whole cow's milk for children [4] (*20*) are shown in table 1. The average annual consumption shown in table 1 for children up to the age of 15 is 820 ml/day. While this figure compares quite well with the average consumption of 800 ml/day reported in the National Consumer Beverage Survey for the winter of 1962 (*21*), the latter summarizes consumption for groups in 6-year increments which is not sufficiently detailed for this study.

Results

Unless otherwise specified, the term "dose" is always the cumulative radiation dose to the thyroid from iodine–131. All of the cumulative doses reported in this study are thyroidal doses received by the average milk-drinking member of the identified subpopulation. While no statement can be made from our calculations about the maximum dose received by any individual, the FRC suggests that no individual is likely to receive a dose greater than three times the average of a population (*9*).

Figure 1 shows the thyroid dose to children born since 1957 where there is a continuous record of measurements of iodine–131 in milk. At all cities, there are clear-cut maxima occurring for children born in 1957. This resulted from the atmospheric weapons tests conducted by the United States, the United Kingdom, and the Soviet Union during that year. While the cumulative doses for children born in January 1957 do not include dose incurred during their second and third trimester in utero exposure and first 6 months after birth, these doses are shown since they are the largest observed even without the previous 12-month exposure. A secondary peak occurred in 1961 which reflects foreign nuclear testing during that year. After the cessation of atmospheric weapons testing with the subsequent implementation of the limited test ban treaty, atmospheric iodine–131 virtually disappeared in the spring of 1963 except for a relatively small amount that has appeared since then. Although the curves are roughly parallel, one can note the considerable variation in the cumulative doses at different cities for a particular cohort (children born the same year). Among the 5 cities with iodine–131 concentration records dating back to 1957, the greatest doses of 1750 mrem and 1625 mrem were received by children born in 1957 in St. Louis and Salt Lake City, respectively. Figures 2 to 10 show the cumulative iodine–131 dose for children in 61 major cities born since 1957 by different geographical regions. The radiation dose estimates in all cases are given from the date of first data as indicated on the figures.

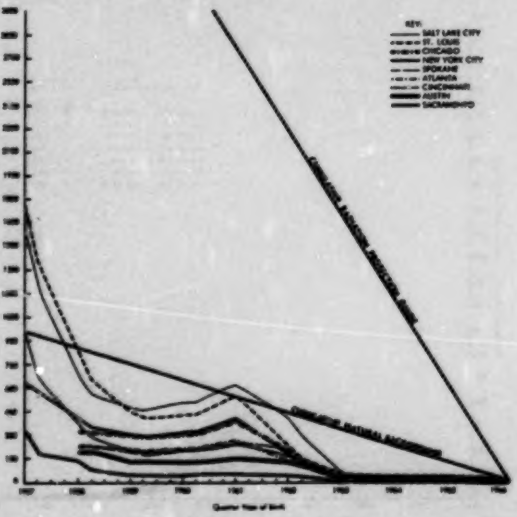

Figure 1. Total thyroid dose from iodine–131 in milk to children born since 1957, contrasted to the cumulative background dose and FRC guidelines

Comparison to natural background

There are a variety of ways in which the results may be compared to doses from natural background, which can yield a variety of conclusions. If one uses an annual natural background dose of 100 mrem (*9*) to individuals in the population, the following observations can be made.

By June 1966, a child born in January 1957 would have received 950 mrem cumulative natural background since birth (figure 1). Thus, children born in 1957 in Cincinnati, Salt Lake City, and St. Louis, would have received man-made doses 1, 2, and 2 times the natural background, respectively, for these cities during these years. Children born in 1961 in St. Louis and Salt Lake City have received equally as much thyroidal exposure from man-made radiation as natural exposure during their first 5½ years of life through June 1966.

At the time that the limited test ban treaty was implemented in 1963, children born in 1957 had received 600 mrem natural exposure. The ratio of the man-made contribution to natural background for the average child born in 1957 in the following 5 cities for which data are available would then have been St. Louis, 3, Salt Lake City, 3, Cincinnati, 2, New York City, 1, and Sacramento, 0.6. If one assumes that the results for the 5 cities (for which 1957 data are available) are applicable to the entire United States, it means that in 1963 the average child of 6 years of age received man-made thyroidal doses from fallout greater than that which he had received from natural radioactivity up to that point in his life. No other known radionuclide from fallout has been found to produce radiation doses comparable to those received from natural background.

In certain years, some man-made doses were much larger than those received from natural background. This fact is indicated by the abrupt changes in slope in the curves in figures 1 to 10.

Applicable guidance

The Federal Radiation Council has established two types of guidelines for limiting radiation exposures to the general population. While neither is particularly applicable for interpreting the doses calculated in this report, comparisons have been made in the belief that they provide a meaningful background for interpretation.

The first of these guidelines, termed Radiation Protection Guide (RPG) was published in May 1960 and is applicable to exposures resulting from controllable sources (*11*). A specific

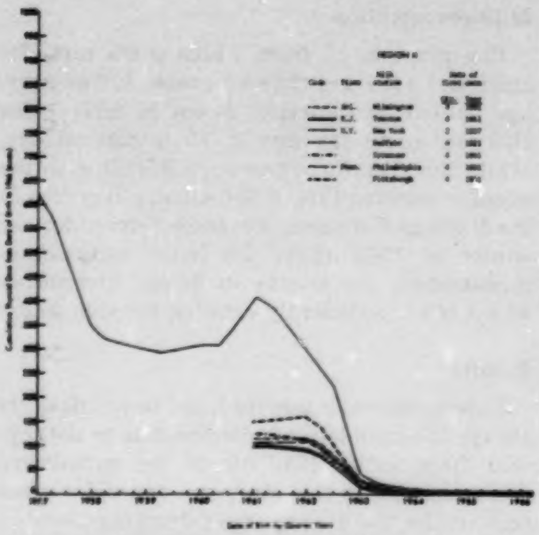

Figure 3. Cumulative iodine-131 dose for children born since 1957 in Region II, by quarter years

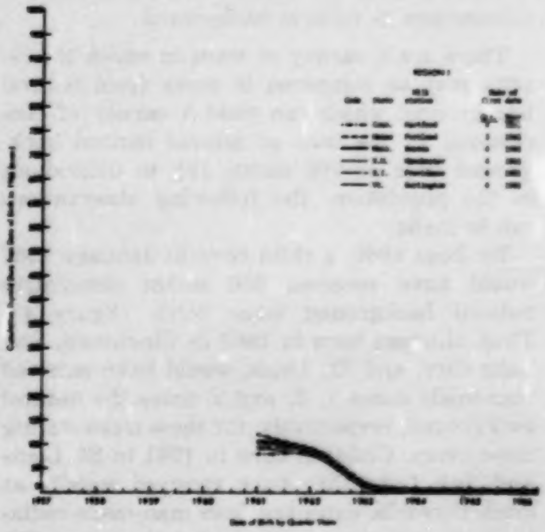

Figure 2. Cumulative iodine-131 dose for children born since 1957 in Region I, by quarter years

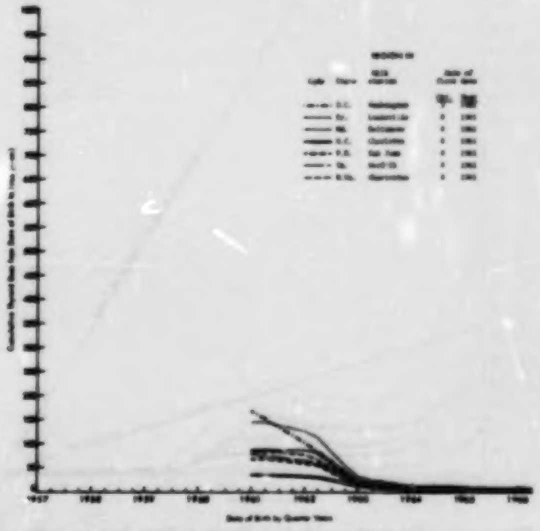

Figure 4. Cumulative iodine-131 dose for children born since 1957 in Region III, by quarter years

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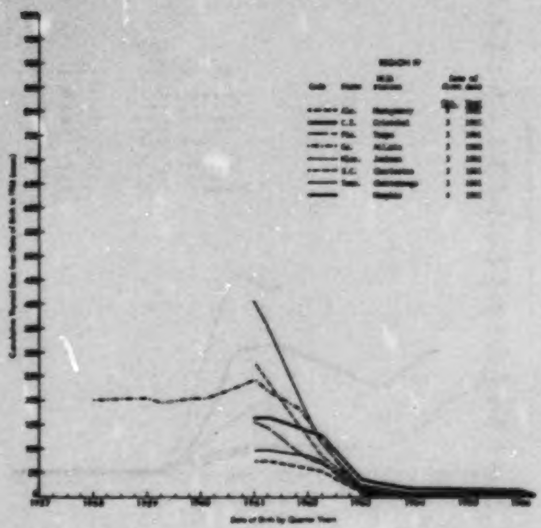

Figure 5. Cumulative iodine-131 dose for children born since 1957 in Region IV, by quarter years

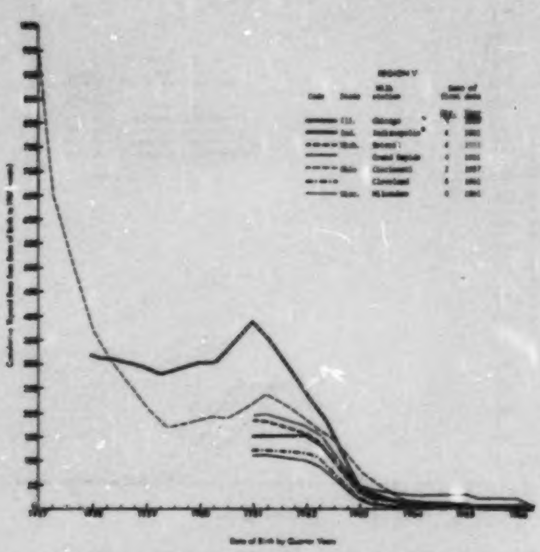

Figure 6. Cumulative iodine-131 dose for children born since 1957 in Region V, by quarter years

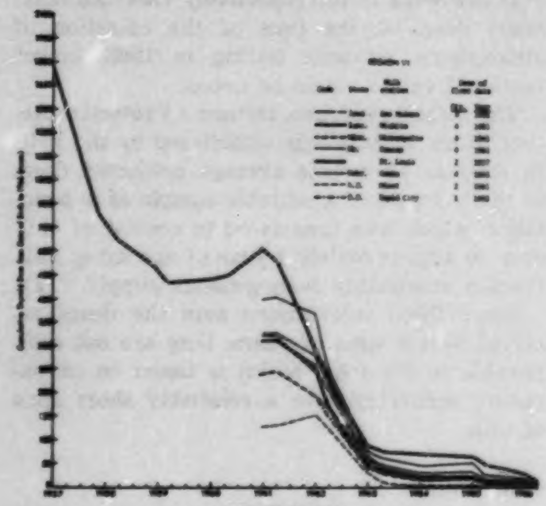

Figure 7. Cumulative iodine-131 dose for children born since 1957 in Region VI, by quarter years

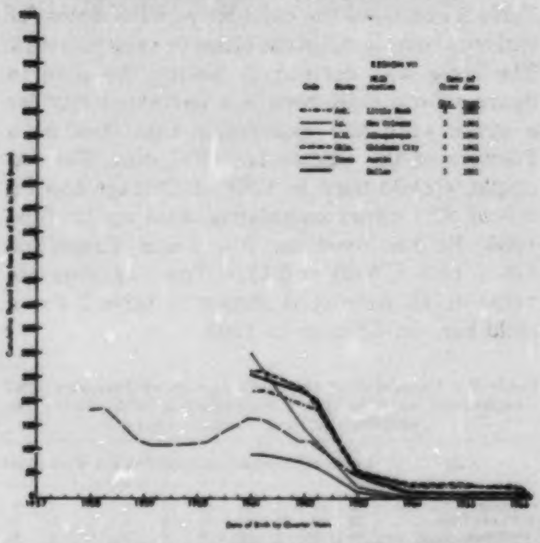

Figure 8. Cumulative iodine-131 dose for children born since 1957 in Region VII, by quarter years

RPG for iodine-131 was published in September 1961 (*8*). Although fallout has been excluded from the category of controllable sources, the FRC subsequently indicated in May 1965 that the RPG could be compared to annual doses from fallout for an indication of need to initiate more careful evaluation of fallout exposures (*10*). Despite the fact that our tabulations of results were based on cumulative exposures and not annual increments, one can reasonably use cumulative exposures as a basis of comparison. The FRC recommended that the RPG for the thyroid gland be 500 mrem per year when applied to the average suitable samples of an exposed group in the general population (*8*).

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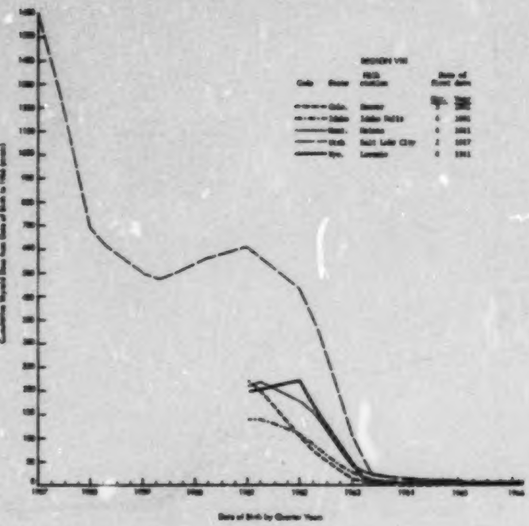

Figure 9. Cumulative iodine-131 dose for children born since 1957 in Region VIII, by quarter years

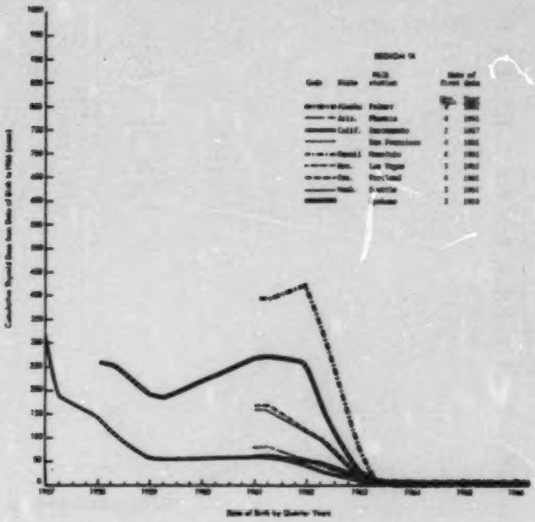

Figure 10. Cumulative iodine-131 dose for children born since 1957 in Region IX, by quarter years

Table 2 expresses the cumulative RPG doses for children born in different cities in various years. The table was derived by noting the dose in figure 1 for a child born in a particular city for a given year and expressing that dose as a fraction of the cumulative RPG dose. For example, a child born in 1961 in Chicago has received 375 mrem cumulative dose up to June 1966. He has lived for 5½ years. Therefore, 375 ÷ (5.5 × 500) = 0.13. The appropriate value of 13 percent is shown in table 2 for a child born in Chicago in 1961.

Table 2. Cumulative thyroid dose as of January 1967 expressed as percent of cumulative RPG doses for children born in various years

City	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966
St. Louis	35	19	11	13	18	10	3	2	3	8
Salt Lake City	32	15	12	15	21	16	3	0	0	0
Cincinnati	19	8	5	6	8	7	1	0	0	0
Chicago	*—	7	7	9	13	8	1	0	0	0
New York City	13	9	8	9	14	7	1	0	0	0
Atlanta	—	5	5	6	9	6	1	0	1	4
Austin	—	4	4	4	5	6	1	0	0	0
Spokane	—	5	5	6	8	8	1	0	0	0
Sacramento	7	3	1	1	2	1	0	0	0	0

* Milk data begins in 1958.

Table 2 shows that the man-made cumulative thyroidal doses in January 1967 are less than the cumulative RPG doses. The subpopulation identified in the table with the largest fractions are children born in 1957; at St. Louis, 40 percent, and at Salt Lake City, 30 percent.

If one were to retrospectively view the man-made doses at the time of the cessation of atmospheric weapons testing in 1963, larger factional values would be noted.

The second guideline, termed a Protective Action Guide (PAG) was established by the FRC in 1964 as 10 mrems average projected doses to the thyroids of a suitable sample of a population which was considered to consist of children of approximately 1 year of age using milk from a reasonably homogeneous supply (*11*).

Since these calculations sum the doses received over a span of years, they are not comparable to the PAG which is based on an exposure occurring over a relatively short span of time.

Conclusions

In the absence of measured concentrations of iodine-131 in thyroids, it is believed that the approach of calculating thyroidal concentrations based on measurements of iodine-131 in milk is the best method available to identify and evaluate previous exposures to children; the subpopulation at greatest risk.

When data are available on the distributions of the model parameters as a function of age, time, location, sex, etc., it is recommended that the calculation of doses to subpopulations on a basis other than average doses. This will produce tabulations subject to more meaningful interpretations by identifying the variation of dose within a given subpopulation. If iodine–131 reappears in the environment, these calculations should be updated periodically. Similarly, the role of radioiodine in foods other than fresh milk for children needs to be more adequately determined.

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, September 1968

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long term concentration trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network, sponsored by the Bureau of Radiological Health and the Bureau of Community Environment Management, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments have also initiated local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides occurring or formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium–89, strontium–90, iodine–131, cesium–137, and barium–140. A sixth radionuclide, potassium–40, occurs naturally in 0.0118 percent abundance of the element potassium (*2*) resulting in a specific activity for potassium–40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both of these elements in milk have

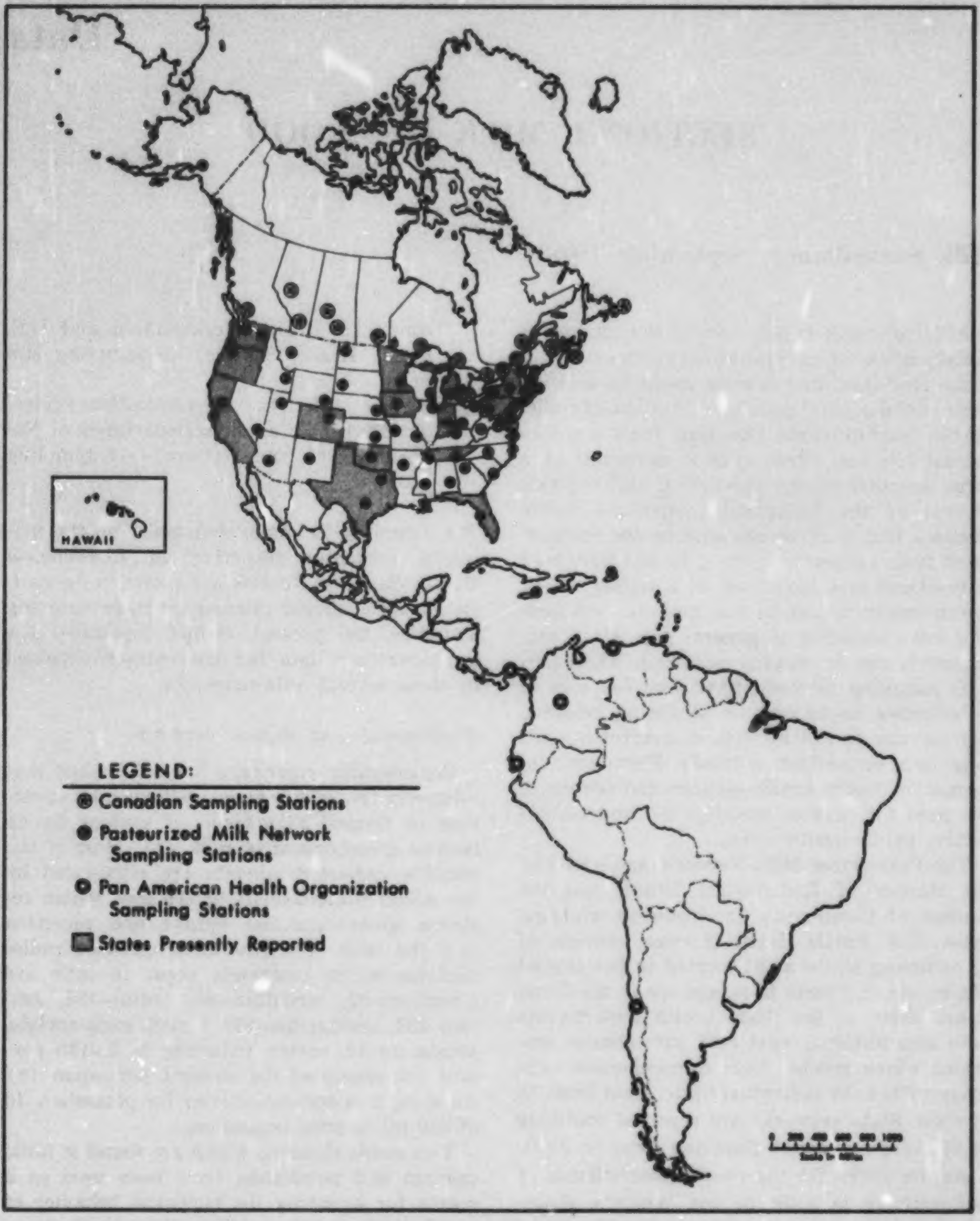
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
○ Pan American Health Organization Sampling Stations
▨ States Presently Reported

Figure 1. Milk sampling networks in the Western Hemisphere reported in *Radiological Health Data and Reports*

been measured extensively and are relatively constant. As a result of a study made of the PHS Pasteurized Milk Network (PMN) results for calcium content in milk for the period, May 1963–March 1966, an average value for the PMN and its 2-standard deviation, 1.16 ± 0.08 g/liter, was developed as an appropriate calcium content in milk for use in general radiological health calculations or discussions (*3*). As a result of a parallel study, an average value for the PMN, 1.51 ± 0.21 g/liter, for potassium content in milk was developed (*3*).

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined in the literature (*4*).

The most recent study was conducted in the spring of 1967, with 40 laboratories participating in an experiment on milk samples containing known concentrations of strontium–90, iodine–131 and cesium–137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 of these laboratories participated in the experiment.

In the majority of cases, the results for the laboratories fell within the 3-standard deviation limits considered appropriate for the various analyses. Several results were outside the 3-standard deviation limits and the most deviant of these represented biases from the expected values of 20–30 percent (*5*).

Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium–40, iodine–131, cesium–137, and barium–140) are determined by gamma-ray spectroscopy on the whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis not only varies among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions will be reflected in the data presentation. While this may appear to complicate comparisons of data, current levels for strontium–90 and cesium–137 are relatively stable over the time periods involved and sampling frequency is not critical. For the case of the short-lived radionuclides, particularly iodine–131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

Also reflected in the data presentation will be whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium–90 and cesium–137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional factors other than radioactivity counting variations such as sample preparation, counting errors not inherent in the minimum detectable activity, and chemical yield variations, it will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium–89	5
Strontium–90	2
Iodine–131	10
Cesium–137	10
Barium–140	10

However, those networks whose practical reporting levels were given as greater than those above will use their reported values, in order that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides would fall in the following ranges:

Radionuclide	Analytical errors of precision 2-standard deviations
Strontium–89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ⩾50 pCi/liter
Strontium–90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ⩾20 pCi/liter
Iodine–131	4–10 pCi/liter for levels <100 pCi/liter; 6–10% for levels ⩾100 pCi/liter
Cesium–137	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ⩾100 pCi/liter
Barium–140	5–10 pCi/liter at levels <100 pCi/liter; 6–10% for levels ⩾100 pCi/liter

For iodine–131, cesium–137, and barium–140, there is one exception for these precision error ranges: which is the 25 pCi/liter at levels <100 pCi/liter for Colorado. The larger Colorado variation at low levels is a result of the counting time and sample volume presently considered practical for evaluation of Colorado milk supplies. This is also reflected in the practical reporting level for that network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance for the use of Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8,9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practical. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

For the purpose of evaluating population exposure, the daily intake of radionuclides by exposed population groups, averaged over a year, constitutes an appropriate criterion. However, in order to provide guidance to Federal agencies in developing appropriate control programs, the FRC described a graded approach involving three ranges of transient rates of daily intake as determined by surveillance, applicable to different degrees of action as follows:

Range I—periodic confirmatory surveillance as necessary,
Range II—quantitative surveillance and routine control,
Range III—evaluation and application of additional control measures, as necessary.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Protective Action Guides (*10,11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Nuclide	Critical organ	RPG for individual in the general population (rad/yr)	RPG (rad/yr)	Guidance for suitable samples of exposed population group[a]			
				Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)[b]	Range II (pCi/day)[b]	Range III (pCi/day)[b]
Strontium-89	Bone	1.5	0.5	[c] 2,000	0-200	200-2,000	2,000-20,000
	Bone marrow	.5	.17				
Strontium-90	Bone	1.5	.5	[c] 200	0-20	20-200	200-2,000
	Bone marrow	.5	.17				
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[d]	Whole body	.5	.17	3,600	0-360	360-3,600	3,600-36,000

[a] Suitable samples which represent the limiting conditions for this guidance are:
Strontium-89, strontium-90—general population
Iodine-131 —children 1 year of age
Cesium-137 —infants

[b] Based on an average intake of 1 liter of milk per day.

[c] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[d] The guides expressed here were not given in the FRC reports, but were calculated using appropropriate FRC recommendations.

benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

FRC reports 5 and 7 set forth PAG's for the thyroid, bone marrow, and whole body doses from ingestion of foods contaminated with radionuclides following an acute contaminating event. For the case of strontium–89, strontium–90, and cesium–137 contamination, the Council defined three categories of dietary pathways in which action may be required following an acute event. The one appropriate to the milk surveillance data is category I—transmission of radionuclides to man through the pasture-cow-milk pathway.

In the case of iodine–131 contamination, the maximum concentration of iodine–131 observed in milk, which may occur 2 to 4 days following an acute incident, can be used to project doses for comparison to the PAG for the thyroid. For strontium–89, strontium–90, and cesium–137, the total dose to the critical organ resulting from contributions of all three of these radionuclides must be considered to determine whether the projected dose will exceed the recommended PAG for the organ of interest (bone marrow or whole body).

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration (*10*). Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in a retrospective manner.

Format for data reporting

Table 3 presents the integrated results of the international, national and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationships between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level. This procedure is required in

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Concentration at maximum in milk for single nuclide that would result in PAG (pCi/liter)
Strontium–89	Bone marrow	10 in first yr; total dose not to exceed 13[a, b]	3 in first yr; total dose not to exceed 5[a, b]	[c] 1,110,000
Strontium–90	Bone marrow			[c] 51,000
Cesium–137	Whole body			[c] 720,000
Iodine–131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium–89 and cesium–137 is the same as dose in first year; total dose from strontium–90 is 5 times strontium–90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered.

order to have numerical monthly concentration estimates that reflect all samples with detectable radioactivity, particularly when average annual intakes are developed.

If the occasion arises when an influx of new contamination occurs, particularly in the case of iodine-131, where sampling frequencies increase and/or the range of radionuclide concentration values for a month are significantly wider than the normal steady-state conditions, a column will be added after the appropriate monthly average reflecting the maximum value for that month. It is the transient maximum value of radionuclide concentrations resulting from an acute contaminating event to which the maximum concentrations in table 2 (derived from the FRC protection guides) can be compared. However, any protective action based on these concentrations being reached will take place immediately on the observance of the high concentrations. Should such cases occur, a more complete discussion of the events would be required and will be provided.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium-90, iodine-131 and cesium-137 for September 1968 and the 12-month period, October 1967–September 1968. Except where noted the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 3, since levels at the great majority of the stations for September 1968 were below the respective practical reporting levels, with the exception of those in table 4.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level of iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 26 pCi/liter in the United States for the month of September 1968. The maximum 12-month average was 21 pCi/liter (Little Rock, Ark., New Orleans, La.), representing 9.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137 monthly averages ranged from 0 to 205 pCi/liter in the United States for the month of September 1968 and the maximum 12-month average was 110 pCi/liter (Central Florida), representing 3.1 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 monthly averages were generally below practical reporting levels, with the following exceptions: Hartford, Conn. (PMN)—3 pCi/liter, 4 samples; Portland, Maine (PMN)—3 pCi/liter, 5 samples; and Nashville, Tenn. (State)—4 pCi/liter, 3 samples.

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Table 3. Concentrations of radionuclides in milk for September 1968 and 12-month period, October 1967 through September 1968

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	8	9	0	0	14(4)	14
Alaska:	Palmer[c]	P	4	6	0	0	13	13
Ariz:	Phoenix[c]	P	0	1	0(4)	0	0(4)	2
Ark:	Little Rock[c]	P	19	21	0(4)	0	12(4)	19
Calif:	Sacramento[c]	P	3	2	0(4)	0	0(4)	5
	San Francisco[c]	P	0	1	0(4)	0	3(4)	5
	Del Norte	P	20	17	0	0	25	20
	Fresno	P	3	0	0	0	0	5
	Humboldt	P	4	4	0	0	16	11
	Los Angeles	P	3	0	0	0	13	7
	Mendocino	P	3	2	0	0	11	5
	Sacramento	P	4	2	0	0	12	6
	San Diego	P	0	0	0	0	0	3
	Santa Clara	P	0	4	0	0	14	7
	Shasta	P	4	3	0	0	16	5
	Sonoma	P	3	2	0	0	12	7
Colo:	Denver[c]	P	6	4	0(4)	0	3(4)	6
	Western	R	d		e	e	e	e
	Northeastern	R	d		e(3)	4	e(3)	e
	Eastern	R	d		NS	e	NS	e
	Southeast	R	d		NS	e	NS	e
	South Central	R	d		NS	e	NS	e
Conn:	Hartford[c]	P	11	10	3(4)	0	11(4)	12
	Central	R	8	8	0(4)	0	7(4)	9
Del:	Wilmington[c]	P	9	11	0(4)	0	11(4)	9
D.C.:	Washington[c]	P	10	10	0(4)	0	0(4)	6
Fla:	Tampa[c]	P	7	8	0(4)	0	82(4)	67
	West	R	14	15	0	9	31	28
	North	R	13	16	0	10	44	46
	Northeast	R	6	9	0	6	72	87
	Central	R	11	10	0	12	99	110
	Tampa Bay area	R	10	6	0	0	92	75
	Southeast	R	10	9	0	3	208	103
Ga:	Atlanta[c]	P	14	15	0(4)	0	22(4)	20
Hawaii:	Honolulu[c]	P	4	3	0	1	0	4
Idaho	Idaho Falls[c]	P	3	6	0(5)	0	7(5)	3
Ill:	Chicago[c]	P	8	9	0(5)	0	10(5)	10
Ind:	Indianapolis[c]	P	9	8	0(5)	0	7(5)	7
	Northeast	P	8	9	0	0	15	8
	Southeast	P	12	10	0	0	16	9
	Central	P	12	8	0	0	2(4)	9
	Southwest	P	6	10	0	0	15	12
	Northwest	P	8	11	0	0	9(4)	11
Iowa:	Des Moines[c]	P	6	7	0(4)	0	6(4)	7
	Iowa City	P	6	7	0	0	12	3
	Des Moines	P	8(5)	7	0(5)	0	10(5)	2
	Spencer	P	7	7	0	0	14	4
	Charles City	P	NS		NS		NS	
Kans:	Wichita[c]	P	5	8	0(5)	0	3(5)	5
Ky:	Louisville[c]	P	15	12	0(4)	0	1(4)	5
La:	New Orleans[c]	P	18	21	0(4)	0	20(4)	23
Maine:	Portland[c]	P	12	12	3(5)	0	34(5)	28
Md:	Baltimore[c]	P	9	10	0(4)	0	6(4)	6
Mass:	Boston[c]	P	11	13	0(4)	0	23(4)	25
Mich:	Detroit[c]	P	8	9	0(4)	0	14	11
	Grand Rapids[c]	P	11	11	0(5)	0	14(5)	14
	Bay City	P	NS	4	NS	0	NS	5
	Charlevoix	P	NS	5	NS	0	NS	7
	Detroit	P	4	5	e(4)	e	3(4)	5
	Grand Rapids	P	5(2)	5	e(5)	e	7(5)	7
	Lansing	P	5(2)	4	e(2)	e	0(2)	3
	Marquette	P	7	7	e(2)	e	25(2)	21
	Monroe	P	3	4	e(2)	e	0(2)	3
Minn:	Minneapolis[c]	P	11	11	0(5)	0	19(5)	13
	Bemidji	P	17	15	0	0	18	21
	Mankato	P	7	6	0	0	0	0
	Rochester	P	6	8	0	0	11	0
	Duluth	P	18	19	0	0	36	25
	Worthington	P	6	6	0	0	13	0
	Minneapolis	P	13	12	0	0	19	10
	Fergus Falls	P	12	10	0	0	0	0
	Little Falls	P	10	9	0	0	31	13
Miss:	Jackson[c]	P	16	17	0(4)	0	13(4)	14
Mo:	Kansas City[c]	P	8	8	0(4)	0	3(4)	5
	St. Louis[c]	P	9	9	0(4)	0	8(4)	8
Mont:	Helena	P	6	5	0(4)	0	17(4)	9
Nebr:	Omaha[c]	P	6	7	0(4)	0	1(4)	5
Nev:	Las Vegas[c]	P	0	1	0(4)	0	3(4)	4
N.H.:	Manchester[c]	P	14	14	0(4)	0	40(4)	36
N.J.:	Trenton[c]	P	8	10	0(4)	0	14(4)	11
N.Mex:	Albuquerque[c]	P	0	2	0(4)	0	3(4)	2

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for September 1968 and 12-month period, October 1967 through September 1968—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
N.Y.:	Buffalo[c]	P	6	9	0(4)	0	7(4)	10
	New York City[c]	P	12	12	0(5)	0	14(5)	14
	Syracuse[c]	P	8	10	0(4)	0	8(4)	6
	Albany	P	9	7	0	0	NA	e
	Buffalo	P	NA	7	NA	0	NA	e
	Massena	P	12	10	NA	0	NA	25
	Newburgh	P	12	10	NA	16	NA	e
	New York City	P	10	10	0	0	e	21
	Syracuse	P	6	7	NA	0	NA	e
N.C.:	Charlotte[c]	P	16	15	0(4)	1	4(4)	11
N.Dak:	Minot[c]	P	13	11	0(5)	0	10(5)	13
Ohio:	Cincinnati[c]	P	8	9	0(4)	0	6(4)	0
	Cleveland[c]	P	7	10	0(4)	0	12(4)	9
Okla:	Oklahoma City[c]	P	9	10	0(5)	0	3(5)	4
	Oklahoma City	P	NA	—	NA	—	NA	—
	Enid	P	NA	—	NA	—	NA	—
	Tulsa	P	NA	—	NA	—	NA	—
	Lawton	P	NA	—	NA	—	NA	—
	Ardmore	P	NA	—	NA	—	NA	—
Ore:	Portland[c]	P	10	7	0(4)	0	19(4)	15
	Baker	P	7	6	e	e	0	4
	Coos Bay	P	0	10	e	e	24	12
	Eugene	P	0	3	e	e	24	12
	Medford	P	0	3	e	e	24	11
	Portland composite	P	6	7	e	e	e(4)	9
	Portland local	P	5	6	e	e	18(4)	13
	Redmond	P	0	4	e	e	18	26
	Tillamook	R	NA	10	e	e	NA	4
Pa:	Philadelphia[c]	P	8	10	0(4)	0	7(4)	9
	Pittsburgh[c]	P	12	13	0(4)	0	9(4)	13
	Dauphin	P	10	8	0	0	26	18
	Erie	P	12	12	0	0	19	23
	Philadelphia	P	15	10	0	0	21	16
	Pittsburgh	P	13	13	0	0	19	10
R.I.:	Providence[c]	P	10	11	0(4)	0	19(4)	18
S.C.:	Charleston[c]	P	12	14	0(4)	0	26(4)	27
S.Dak:	Rapid City[c]	P	12	10	0(5)	0	14(5)	11
Tenn:	Chattanooga[c]	P	17	14	0(5)	0	13(5)	13
	Memphis[c]	P	11	11	0(5)	0	0(2)	5
	Chattanooga	P	12	13	0(5)	1	17(5)	18
	Clinton	P	10	13	0(5)	3	19	21
	Knoxville	P	9	12	0(5)	4	14(5)	15
	Nashville	P	8	8	4(5)	1	11	18
Tex:	Austin[c]	P	3	4	0(4)	0	0(4)	2
	Dallas[c]	P	9	8	0(5)	0	3(5)	5
	Amarillo	R	NA	5	NA	0	NA	0
	Corpus Christi	R	NA	4	NA	0	NA	4
	El Paso	R	NA	1	NA	0	NA	0
	Fort Worth	R	NA	6	NA	0	NA	0
	Harlingen	R	NA	1	NA	0	NA	0
	Houston	R	NA	11	NA	0	NA	8
	Lubbock	R	NA	4	NA	0	NA	0
	Midland	R	NA	3	NA	0	NA	0
	San Antonio	R	NA	3	NA	0	NA	0
	Texarkana	R	NA	11	NA	0	NA	10
	Uvalde	R	NA	1	NA	0	NA	0
	Wichita Falls	R	NA	9	NA	0	NA	0
Utah:	Salt Lake City[c]	P	10	6	0(4)	0	19(4)	13
Vt:	Burlington[c]	P	10	11	0(4)	0	4(4)	9
Va:	Norfolk[c]	P	10	11	0(4)	0	6(4)	9
Wash:	Seattle[c]	P	7	9	0(4)	0	20(4)	21
	Spokane[c]	P	5	7	0(4)	0	11(4)	11
	Benton County	R	0	0	0	0	18	3
	Deer Park	R	0	3	0	0	e	2
	Elma	R	6	4	0	0	22	20
	Franklin County	R	NS	0	NS	0	NS	e
	Moses Lake	R	0	1	0	0	e	e
	Pierce County	R	3	3	0	0	15	8
	Sandpoint, Idaho	R	3	7	0	0	25	22
	Skagit County	R	6	4	0	0	20	14
W.Va:	Charleston[c]	P	16	12	0(4)	0	3(4)	4
Wisc:	Milwaukee[c]	P	8	8	0(5)	0	7(5)	10
Wyo:	Laramie[c]	P	0	4	0(4)	0	1(4)	7
CANADA:								
Alberta:	Calgary	R	8	9	d		22	18
	Edmonton	R	10	8	d		28	22
British Columbia:	Vancouver	R	14	14	d		60	81
Manitoba:	Winnipeg	R	8	8	d		28	24
New Brunswick:	Fredericton	R	15	18	d		28	24

See footnotes at end of table.

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Table 3. Concentrations of radionuclides in milk for September 1968 and 12-month period, October 1967 through September 1968—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA (Continued)								
Newfoundland:								
	St. Johns	R	27	21	d		38	41
Nova Scotia:	Halifax	R	12	12	d		23	24
Ontario:	Ft. William	R	19	16	d		42	29
	Ottawa	R	7	9	d		22	19
	Sault Ste. Marie	R	17	15	d		50	31
	Toronto	R	5	5	d		15	15
	Windsor	R	6	5	d		20	14
Quebec:	Montreal	R	8	10	d		21	20
	Quebec	R	10	13	d		30	28
Saskatchewan:								
	Regina	R	8	8	d		20	15
	Saskatoon	R	10	9	d		24	18
CENTRAL AND SOUTH AMERICA:								
Columbia:	Bogota	P	3	1	0	0	0	2
Chile:	Santiago	P	0	0	0	0	0	0
Ecuador:	Guayaquil	P	0	0	0	0	0	2
Jamaica:	Montego Bay	P	9	5	0	0	245	125
Venezuela	Caracas	P	3	1	0	0	0	0
Canal Zone:	Cristobal[c]	P	3	1	0(4)	1	18(4)	9
Puerto Rico:	San Juan[c]	P	5	5	0(4)	0	7(4)	10

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or national network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon —15 pCi/liter

Cesium-137: Colorado —25 pCi/liter
New York —20 pCi/liter
Oregon —15 pCi/liter
Washington—15 pCi/liter

Strontium-90: New York—3 pCi/liter

NA, no analysis.
NS, no sample collected.

Table 4. Reported concentrations of strontium-89 and barium-140 in milk

Strontium-89		Barium-140	
Sampling location	Monthly average (pCi/liter)	Sampling location	Monthly average (pCi/liter)
Idaho: Idaho Falls (PMN)	6	Calif: Del Norte (State)	14
Tenn: Clinton (State)	15	Humboldt	14
Knoxville	10	Mendocino	12
Canal Zone:		Fla:	
Cristobal (PMN)	20	North (State)	18
Columbia:		Central	26
Bogata (PAHO)	15	Southeast	21
Chile:		Maine:	
Santiago (PAHO)	20	Portland (PMN)	3(5)[a]
Ecuador:		Mo:	
Guayaquil (PAHO)	15	Kansas City (PMN)	3(4)
Jamaica: Montego Bay (PAHO)	15	St. Louis	3(4)
		Nev: Las Vegas (PMN)	3(4)
		S. Dak: Rapid City (PMN)	3(5)

[a] Number in parentheses indicates number of samples.

(5) KAUFFMAN, P., and F. KNOWLES. Interlaboratory study of iodine–131, cesium–137 and strontium–90 measurements in milk, March–April 1967.

(6) NEILL, R. H. and D. R. SNAVELY. State Health Department sampling criteria for surveillance of radioactivity in milk. Radiol Health Data Rep 8:621–627 (November 1967).

(7) ROBINSON, P. B. A comparison of results between the Public Health Service raw milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

(8) FEDERAL RADIATION COUNCIL. Background materials for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).

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(10) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).

(11) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action guides for strontium–89, strontium–90, and cesium–137, Report No. 7. Superintendent of Documents, U.S. Printing Office, Washington, D.C. 20402 (May 1965).

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Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation and Occupational Health Section
Division of Environmental Sanitation
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provides a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	July–October 1967	May 1968
Connecticut Standard Diet	January–June 1968	November 1968
Tri-City Diet, HASL	April–December 1967	June 1968

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1. Radionuclides in Institutional Diet Samples
April-June 1968

Bureau of Community Environment Management

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Bureau of Radiological Health with the assistance of the Bureau of Community Environment Management (*1*).

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 1965, 21 basic institutions, and 8 auxiliary institutions, distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1–2*). Consequently, estimates for boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks), obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev.; the Southeastern Radiological Health Laboratory, Montgomery, Ala.; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented earlier (*3*).

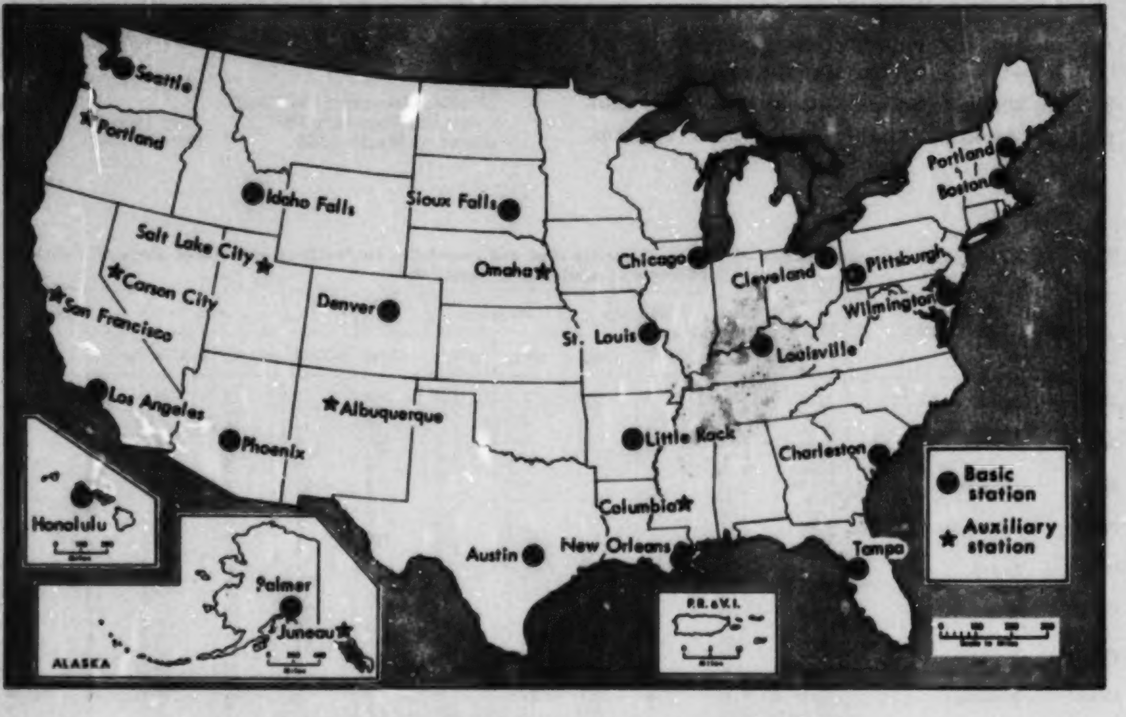
Seattle
Portland
Idaho Falls
Sioux Falls
Salt Lake City
Omaha
Carson City
Denver
Chicago
Cleveland
Pittsburgh
Portland
Boston
Wilmington
San Francisco
St. Louis
Louisville
Los Angeles
Albuquerque
Phoenix
Little Rock
Charleston
Honolulu
Columbia
Basic station
Auxiliary station
Austin
New Orleans
Tampa
Palmer
Juneau
ALASKA
P.R. & V.I.

Figure 1. Instiutional diet sampling locations as of June 1968

Results

Table 1 presents the analytical results for institutional diet samples collected from April through June 1968, for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of these samples, reported in pCi/kg of diet, are corrected for radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes, in g/day or pCi/day, were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.80 kg/day compared to the network average of 1.86 kg/day observed from 1961 through 1967.

Strontium-90 dietary intake during this period averaged 15 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (4). Cesium-137 intakes averaged 24 pCi/day during this period. Strontium-89, barium-140, and iodine-131 concentrations were generally below detectable levels.

All concentrations that are less than or equal to the appropriate minimum detectable level will be reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2-standard deviation analytical error. Accordingly, the minimum detectable limits are as follows:

Strontium-89	5 pCi/kg
Strontium-90	2 pCi/kg
Iodine-131	10 pCi/kg
Cesium-137	10 pCi/kg
Barium-140	10 pCi/kg
Radium-226	0.1 pCi/kg

Data from eight auxiliary stations is included in a separate table for general information. This is presented in table 2. These stations do not meet the criterion that the majority of the samples are collected from children who range in age from 9 to 12 years. In order to supplement the existing environmental monitoring networks of the Bureau of Radiological Health, these eight institutions are being sampled in the same manner as the basic stations.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1967 and annual Summary 1967	July 1968
January–March 1968	October 1968

Table 1. Concentrations and intake of stable elements and radionuclides in institutional total diets of children (9–12 years of age), April–June 1968

Location of Institution	Month	Total weight (kg/day)	Calcium		Potassium		^{90}Sr		^{137}Cs		^{226}Ra	
			g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska: Palmer	April	1.56	0.5	0.7	1.2	1.9	9	13	16	25	0.4	0.6
	May	1.53	.7	1.0	1.5	2.2	NA	NA	20	31	.7	1.1
	June	1.94	.4	.8	1.2	2.3	8	16	16	31	.4	.8
Ariz: Phoenix	April	2.00	NA	NA	1.2	2.4	NA	NA	13	26	.5	1.0
	May	2.01	.5	1.0	1.3	2.5	NA	NA	0	0	.4	.8
	June	1.99	.6	1.1	1.7	3.4	5	9	0	0	.7	1.4
Ark: Little Rock	April	1.77	.6	1.0	1.6	2.8	9	16	14	25	.6	1.1
	May	1.80	.6	1.1	1.8	3.2	15	27	19	34	.5	.9
	June	1.85	.5	.9	1.4	2.5	10	19	0	0	.4	.7
Calif: Los Angeles	April	1.70	.5	.8	1.2	2.0	5	8	0	0	.7	1.2
	May	1.74	.7	1.3	1.1	1.9	NA	NA	0	0	.5	.9
	June	1.50	.5	.8	1.2	1.7	3	5	0	0	.4	.6
Colo: Denver	April	2.40	.7	1.8	1.6	3.7	8	19	0	0	.6	1.4
	May[a]	2.34	.6	1.3	1.3	3.0	NA	NA	0	0	.3	.7
	June[a]	2.46	.7	1.7	1.2	3.0	5	12	0	0	.5	1.2
Del: Wilmington	April	2.22	.7	1.5	1.5	3.2	7	15	14	31	.7	1.6
	May	2.26	.7	1.6	1.6	3.7	8	18	11	25	.9	2.0
	June	2.05	.7	1.5	1.5	3.1	9	18	14	29	.8	1.6
Fla: Tampa	April	2.20	.5	1.2	1.8	3.9	6	13	28	62	.6	1.3
	May	2.23	.6	1.4	1.7	3.8	8	18	40	89	.7	1.6
	June	2.02	.6	1.2	1.8	3.6	7	14	24	48	.5	1.0
Hawaii: Honolulu	April	2.27	.4	1.0	1.4	3.3	3	6	15	34	.4	.9
	May	2.25	.5	1.1	1.3	2.9	3	7	0	0	.6	1.4
	June	2.32	.5	1.1	1.3	2.9	7	16	15	35	.4	.9
Idaho: Idaho Falls	April[a]	2.17	1.3	2.9	1.4	3.0	12	26	13	28	.2	.4
	May[a]	2.06	.7	1.5	1.6	3.3	8	15	13	27	.5	1.0
	June[a]	2.12	.9	1.8	1.6	3.4	8	18	19	40	.5	1.1
Ill: Chicago	April[a]	1.25	.8	1.0	1.7	2.1	7	9	15	19	.6	.8
	May	1.56	.7	1.1	1.5	2.3	6	10	14	22	.8	1.2
	June	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Ky: Louisville	April	1.11	.5	.6	1.6	1.8	9	10	0	0	.9	1.0
	May	1.00	.4	.4	1.7	1.7	8	8	0	0	1.0	1.0
	June	.55	.4	.2	1.4	.8	13	7	0	0	1.2	.7
La: New Orleans	April	1.61	.7	1.0	1.7	2.7	16	25	18	29	.5	.8
	May	1.87	.6	1.0	1.7	3.1	13	24	14	26	.5	.9
	June	1.65	.6	1.0	1.5	2.5	11	18	12	20	.6	1.0
Maine: Portland	April	1.83	.8	1.4	1.6	2.9	10	19	20	37	.6	1.1
	May	1.61	.9	1.4	1.3	2.2	16	26	39	63	.8	1.3
	June	1.59	1.0	1.5	1.6	2.5	15	24	30	48	.9	1.4
Mass: Boston	April	1.46	.8	1.1	1.7	2.4	9	13	19	28	.6	.9
	May	1.65	.7	1.2	1.4	2.4	8	14	13	21	.8	1.3
	June	1.56	.8	1.2	1.4	2.2	9	14	25	39	.7	1.1
Mo: St. Louis	April	2.61	.8	2.2	1.6	4.0	14	37	0	0	.9	2.3
	May	2.65	1.0	2.6	1.6	4.2	9	23	12	32	.8	2.1
	June[a]	2.19	1.0	2.2	1.4	3.0	12	26	23	50	.9	2.0
Ohio: Cleveland	April	1.55	.7	1.1	1.6	2.4	8	12	19	29	.3	.5
	May	1.38	.8	1.1	1.6	2.1	8	11	19	26	.7	1.0
	June	1.19	.6	.7	1.6	1.9	4	5	16	19	.5	.6
Pa: Pittsburgh	April	2.19	.6	1.3	1.5	3.3	8	18	15	33	.6	1.3
	May	2.28	.6	1.3	1.6	3.7	8	18	14	32	.8	1.8
	June	2.13	.6	1.2	1.5	3.1	8	17	25	53	.8	1.7
S.C.: Charleston	April	1.27	.7	.9	1.5	1.9	9	12	14	18	.5	.6
	May	1.72	.8	1.3	1.7	2.9	10	16	22	38	.8	1.4
	June	1.16	.6	.7	1.5	1.7	9	10	18	21	.6	.7
S.Dak: Sioux Falls	April	1.33	.7	.9	1.2	1.6	6	8	0	0	.8	1.1
	May[a]	1.66	1.0	1.7	1.5	2.4	12	20	36	60	1.7	2.8
	June[a]	1.31	.6	.7	1.5	2.0	5	7	0	0	.6	.8
Tex: Austin	April	1.93	.7	1.4	1.6	3.1	4	8	0	0	.4	.8
	May	2.08	.8	1.6	1.7	3.5	5	11	12	25	.5	1.0
	June	1.81	.7	1.3	1.5	2.7	4	8	0	0	.7	1.3
Wash: Seattle	April	1.87	.6	1.0	1.6	2.9	5	10	16	30	.3	.6
	May[a]	1.96	.8	1.5	1.5	2.9	NA	NA	18	36	.7	1.4
	June[a]	1.89	.7	1.4	1.5	2.8	10	20	15	28	.7	1.3
Institutional average	April	1.84	0.6	1.2	1.5	2.7	8	15	12	21	0.6	1.1
	May	1.86	0.7	1.3	1.5	2.8	9	17	15	27	0.7	1.3
	June	1.69	0.6	1.0	1.5	2.5	8	13	13	23	0.6	1.0

[a] Since food samples were collected from two or more children who were not between the ages of 9–12, data for this month were not used in institutional average.

NS, no sample.

NA, no analysis.

Note: Since iodine-131, barium-140 and strontium-89 were not detectable at most stations during the second quarter of 1968, no provision was made for these nuclides in the table. The few exceptions are as follows: iodine-131 was reported in April for Ohio, 13 pCi/kg; barium-140 was reported in April for Ohio, 15 pCi/kg; and also reported in June for Delaware, 17 pCi/kg.

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Table 2. Concentrations and intake of stable elements and radionuclides in institutional total diets of individuals (auxiliary stations) April–June 1968

Location of Institution		Month	Total weight (kg/day)	Calcium		Potassium		^{90}Sr		^{137}Cs		^{226}Ra	
				g/kg	g/day	g/kg	g/day	pCi/kg	pCi/day	pCi/kg	pCi/day	pCi/kg	pCi/day
Alaska:	Juneau	April	1.51	0.4	0.5	1.2	1.8	5	8	0	0	0.3	0.5
		May	1.48	.6	.9	1.7	2.5	NA	NA	19	28	.4	.6
		June	1.27	.4	.5	1.8	2.3	5	6	15	19	.3	.4
Calif:	San Francisco	April	1.89	.7	1.2	1.7	3.1	4	8	21	40	1.1	2.1
		May	2.25	1.1	2.5	1.5	3.4	NA	NA	0	0	.6	1.4
		June	2.03	.7	1.5	1.5	3.1	7	13	0	0	.6	1.2
Miss:	Columbia	April	2.64	.9	2.4	1.4	3.7	13	34	0	0	.6	1.6
		May	2.11	.8	1.7	1.4	3.0	11	22	19	40	.5	1.1
		June	1.72	.7	1.2	1.4	2.4	16	28	13	22	.5	.9
Nebr:	Omaha	April	2.08	.9	1.9	1.6	3.2	6	13	0	0	.6	1.2
		May	2.04	1.2	2.5	1.7	3.5	8	16	0	0	1.3	2.7
		June	2.04	.8	1.7	1.4	2.9	6	12	12	24	.7	1.4
Nev:	Carson City	April	1.79	NA	NA	1.3	2.4	NA	NA	13	23	.7	1.3
		May	1.40	.7	1.0	2.1	2.9	NA	NA	11	15	.6	.8
		June	1.32	.7	.9	1.9	2.5	4	5	11	15	.6	.8
N. Mex:	Albuquerque	April	2.22	.6	1.3	1.5	3.3	4	9	0	0	.4	.9
		May	2.23	.6	1.4	1.6	3.7	5	11	0	0	.5	1.1
		June	1.31	.6	.8	1.6	2.1	6	8	0	0	.6	.8
Ore:	Portland	April	2.22	.6	1.3	1.6	3.6	6	13	20	44	.4	.9
		May	2.33	.6	1.3	1.6	3.8	NA	NA	14	33	.4	.9
		June	2.31	.6	1.4	1.6	3.7	6	14	23	53	.4	.9
Utah:	Salt Lake City	April	1.97	.5	.9	1.0	2.0	5	11	11	22	.3	.6
		May	1.70	.8	1.4	1.4	2.4	NA	NA	0	0	.6	1.0
		June	2.26	.6	1.4	1.2	2.7	5	11	12	27	.4	.9
Institutional average		April	2.04	0.7	1.4	1.4	2.9	6	14	8	16	0.6	1.1
		May	1.94	0.8	1.6	1.6	3.2	8	16	8	15	0.6	1.2
		June	1.78	0.6	1.2	1.6	2.7	7	12	11	20	0.5	0.9

NA, no analysis.

Note: Since iodine-131, barium-140 and strontium-89 were not detected at most stations during the second quarter of 1968, no provision was made for these nurlides in the table. The few exceptions are as follows: strontium-89 was reported in April for California, 7 pCi/kg and Oregon, 10 pCi/kg.

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(3) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1968. Radiol Health Data 9:557–560 (October 1968).

(4) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standard, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

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SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Last presented
California	July–December 1967	December 1968
Colorado River Basin	1967	December 1968
Florida	1965–1966	July 1968
Minnesota	July–December 1967	October 1968
New York	June–December 1967	October 1968
Radiostrontium in Tap Water, HASL	January–June 1967	April 1968
Washington	July 1966–June 1967	August 1968

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(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

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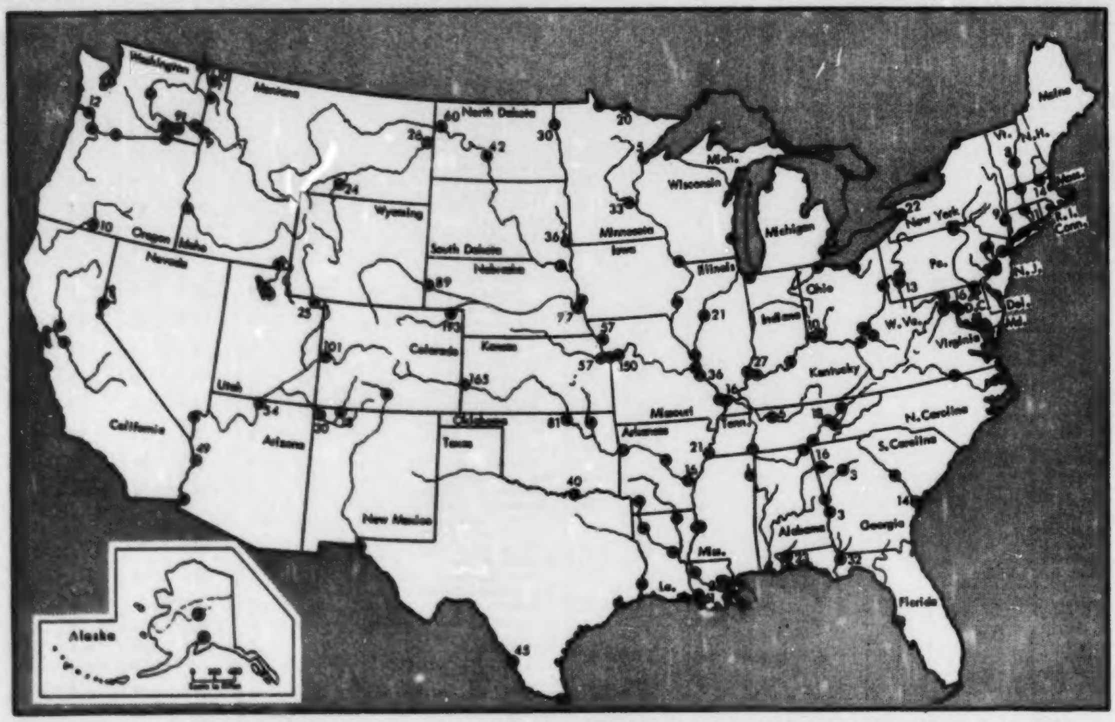
Gross Radioactivity in Surface Waters of the United States, July 1968

Division of Pollution Surveillance
Federal Water Pollution Control Administration, Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System currently operated by the Federal Water Pollution Control Administration. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the November 1968 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveil-


Washington
Montana
North Dakota
Minnesota
Wisconsin
Mich.
Michigan
Maine
Vt.
N.H.
Mass.
R.I.
Conn.
New York
Pa.
N.J.
Del.
Md.
D.C.
Oregon
Idaho
Wyoming
South Dakota
Nebraska
Iowa
Illinois
Indiana
Ohio
W.Va.
Virginia
Kentucky
Nevada
Utah
Colorado
Kansas
Missouri
California
Arizona
New Mexico
Oklahoma
Texas
Arkansas
Tenn.
N.Carolina
S.Carolina
Miss.
Alabama
Georgia
La.
Florida
Alaska
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91
10
60
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42
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36
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89
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193
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190
101
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14
32

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, July 1968

lance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During July 1968, the following stations showed values in excess of 15 pCi/liter on alpha radioactivity for either suspended or dissolved solids: Arkansas River, Coolidge, Kans.; North Platte River, Henry, Nebr.; South Platte River, Julesburg, Colo. Julesburg, Colo., on the South Platte River showed beta radioactivity for dissolved solids in excess of 150 pCi/liter. No reason for this relatively high level is apparent, however, if river flows were unusually low, this level of radioactivity may be produced. The beta dissolved radioactivity on the Columbia River at Pasco, Wash., is considerably below 150 pCi/liter. This may be due to decreased reactor operations.

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*2*) *Ibid.*, 1959 Edition.

(*3*) *Ibid.*, 1960 Edition.

(*4*) *Ibid.*, 1961 Edition.

(*5*) *Ibid.*, 1962 Edition.

(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*7*) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–15 (January 1968).

Table 1. Radioactivity in raw surface waters, July 1968

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	0	2	2	1	17	18
Apalachicola River:						
Chattahoochee, Fla	1	0	1	2	30	32
Arkansas River:						
Coolidge, Kans	21	38	59	58	107	165
Ponca City, Okla	10	2	12	34	47	81
Pendleton Ferry, Ark	0	0	0	1	15	16
Atchafalaya River:						
Morgan City, La	13	1	14	46	15	61
Big Horn River:						
Hardin, Mont	0	3	3	6	18	24
Big Sioux River:						
Sioux Falls, S. Dak	1	3	4	5	31	36
Chattahoochee River:						
Atlanta, Ga	0	0	0	1	2	3
Columbus, Ga	0	0	0	0	3	3
Clearwater River:						
Lewiston, Idaho	0	0	0	2	7	9
Clinch River:						
Kingston, Tenn[a]	0	<1	<1	2	16	18
Colorado River:						
Loma, Colo	6	8	14	42	59	101
Page, Ariz	0	5	5	3	51	54
Parker Dam, Calif-Ariz	0	13	13	1	48	49
Columbia River:						
Pasco, Wash[a]	<1	<1	<1	37	54	91
Clatskanie, Ore	0	1	1	1	11	12
Connecticut River:						
Wilder, Vt	1	0	1	2	6	8
Enfield Dam, Conn	0	0	0	1	10	11
Coosa River:						
Rome, Ga	<1	0	<1	6	10	16
Cumberland River:						
Cheatham Lock, Tenn	0	0	0	0	6	6
Escambia River:						
Century, Fla	1	1	2	5	18	23
Great Lakes:						
Duluth, Minn	0	0	0	1	4	5
Buffalo, N.Y	0	1	1	2	20	22
Green River:						
Dutch John, Utah	0	4	4	1	24	25
Hudson River:						
Poughkeepsie, N.Y	0	0	0	1	8	9
Illinois River:						
Peoria, Ill	2	2	4	3	18	21
Kansas River:						
DeSoto, Kans	2	2	4	20	37	57
Klamath River:						
Keno, Ore	0	0	0	2	8	10
Merrimack River:						
Lowell, Mass	0	0	0	8	6	14
Mississippi River:						
St. Paul, Minn	1	2	3	6	27	33
E. St. Louis, Ill	6	2	8	17	19	36
W. Memphis, Ark	1	1	2	8	13	21
New Orleans, La	3	3	6	8	18	26
Missouri River:						
Williston, N. Dak	5	1	6	37	23	60
Bismarck, N. Dak	1	5	6	7	35	42
St. Joseph, Mo	4	2	6	31	26	57
Missouri City, Mo	12	3	15	116	34	150
Monongahela River:						
Pittsburgh, Pa	0	0	0	3	10	13
North Platte River:						
Henry, Nebr	3	26	29	15	74	89
Ohio River:						
Cincinnati, Ohio	0	1	1	2	8	10
Cairo, Ill	0	1	1	1	15	16
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	<1	<1	2	8	10
Platte River:						
Plattsmouth, Nebr	10	4	14	44	33	77
Potomac River:						
Washington, D.C	0	0	0	5	11	16
Rainy River:						
Baudette, Minn	1	1	2	3	17	20
Red River, North:						
Grand Forks, N. Dak	1	1	2	5	25	30
Red River, South						
Denison, Tex	1	2	3	3	37	40
Rio Grande:						
Laredo, Tex	5	3	8	20	25	45
San Juan River:						
Shiprock, N. Mex	3	3	6	7	23	30
Savannah River:						
Port Wentworth, Ga[a]	1	<1	1	3	11	14
South Platte River:						
Julesburg, Colo	8	54	62	35	158	193
Wabash River:						
New Harmony, Ind	1	1	2	10	17	27
Yellowstone River:						
Sidney, Mont	4	2	6	13	13	26
Maximum	21	54	62	116	158	193
Minimum	0	0	0	0	2	3

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
HASL Fallout Network	July–December 1967	September 1968
HASL 80th Meridian Network	Calendar Year 1966	December 1968

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1. Radiation Alert Network
September 1968

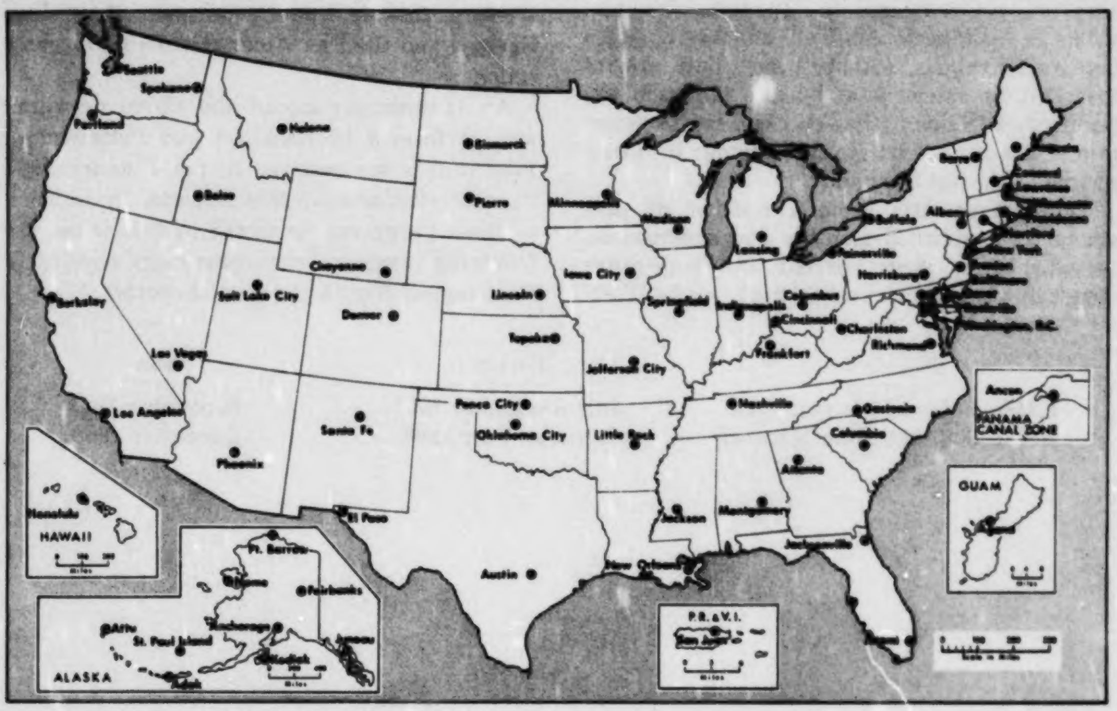
Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during September 1968. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.


Seattle
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Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Lansing
Cheyenne
Salt Lake City
Iowa City
Berkeley
Lincoln
Denver
Springfield
Indianapolis
Columbus
Cincinnati
Charleston
Topeka
Frankfort
Richmond
Las Vegas
Jefferson City
Harrisburg
Buffalo
Albany
Barre
New York
Washington, D.C.
Los Angeles
Ponca City
Oklahoma City
Santa Fe
Little Rock
Nashville
Gastonia
Columbia
Atlanta
Phoenix
Jackson
Montgomery
Jacksonville
El Paso
New Orleans
Austin
Honolulu
HAWAII
Pt. Barrow
Nome
Fairbanks
Attu
St. Paul Island
Anchorage
Kodiak
Adak
Juneau
ALASKA
Miles
P.R. & V.I.
San Juan
Ancon
PANAMA CANAL ZONE
GUAM
Scale in Miles

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, September 1968

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m^3)			Last profile in RHD&R	Precipitation				
							Number or samples	Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average[a]				Number of samples	Depth (mm)	Total deposition (nCi/m^2)
Ala:	Montgomery	20	7	0	4	Sept 68	1	40	1	40	0
Alaska:	Adak	33	3	1	2	Apr 68	(c)				
	Anchorage	14	0	0	0	Oct 68	(c)				
	Attu Island	(b)				May 68	(c)				
	Fairbanks	1	2	2	2	Nov 68	(c)				
	Juneau	7	0	0	0	Dec 68	19	406	19	406	0
	Kodiak	20	2	0	0	Jan 69	(c)				
	Nome	(b)				July 68	(c)				
	Point Barrow	10	2	0	1	June 68	(c)				
	St. Paul Island	30	1	1	1	Aug 68	(c)				
Ariz:	Phoenix	19	10	2	6	Dec 68	(c)				
Ark:	Little Rock	6	4	1	2	Oct 68	2	106	2	106	0
Calif:	Berkeley	19	1	0	0	Jan 69	(c)				
	Los Angeles	(b)				July 68	(c)				
C.Z:	Ancon	15	0	0	0	Jan 69	(c)				
Colo:	Denver	17	7	1	4	Jan 69	(c)				
Conn:	Hartford	19	0	0	0	Nov 68	4	43	4	43	3
Del:	Dover	19	1	0	1	Sept 68	(c)				
D.C.:	Washington	9	3	0	1	June 68	(c)				
Fla:	Jacksonville	20	2	0	1	Oct 68	6	48	6	48	44
	Miami	21	1	0	0	Nov 68	12	174	10	170	0
Ga:	Atlanta	19	2	1	1	Aug 68	2	32	2	32	20
Guam:	Agana	(b)				Sept 68	(c)				
Hawaii:	Honolulu	29	1	0	1	May 68	1	10	0	0	(e)
Idaho:	Boise	30	7	1	4	May 68	1	7	1	7	0
Ill:	Springfield	7	5	0	1	June 68	3	8	0	0	(e)
Ind:	Indianapolis	19	8	0	2	Aug 68	5	24	5	24	28
Iowa:	Iowa City	16	3	0	1	Jan 69	9	84	9	84	0
Kans:	Topeka	20	4	0	2	Oct 68	7	78	7	78	4
Ky:	Frankfort	19	4	0	2	June 68	7	41	7	41	34
La:	New Orleans	18	7	0	1	June 68	5	41	0	0	(e)
Maine:	Augusta	19	2	0	1	Dec 68	5	39	5	39	0
Md:	Baltimore	19	2	0	1	Nov 68	3	18	3	18	2
	Rockville	14	3	0	1	May 68	(c)				
Mass:	Lawrence	19	2	0	1	Sept 68	4	38	4	38	33
	Winchester	18	4	0	1	Apr 68	5	36	5	36	0
Mich:	Lansing	19	3	1	2	May 68	9	79	9	[illegible]	270
Minn:	Minneapolis	21	5	0	0	Sept 68	8	122	8	[illegible]	189
Miss:	Jackson	19	9	0	1	Dec 68	3	49	3	49	45
Mo:	Jefferson City	19	4	0	1	Aug 68	8	133	8	[illegible]	0
Mont:	Helena	20	9	1	3	Apr 68	7	7	7	7	19
Nebr:	Lincoln	19	4	0	2	Aug 68	7	159	6	158	22
Nev:	Las Vegas	18	5	1	3	Nov 68	(c)				
N.H.:	Concord	19	3	1	1	June 68	(c)				
N.J:	Trenton	17	3	0	2	Dec 68	1	11	1	11	13
N. Mex:	Santa Fe	18	2	0	1	Apr 68	2	17	2	17	0
N.Y:	Albany	19	7	0	2	Aug 68	5	42	5	42	54
	Buffalo	20	1	0	1	Jan 69	(c)				
	New York City	20	2	0	1	Apr 68	(c)				
N.C:	Gastonia	15	12	2	6	Jan 69	3	83	(d)		
N. Dak:	Bismarck	18	4	0	2	June 68	5	38	4	18	15
Ohio:	Cincinnati	(b)				Sept 68	(c)				
	Columbus	16	4	0	2	Dec 68	7	71	0	0	(e)
	Painesville	20	2	0	1	Nov 68	9	37	9	37	0
Okla:	Oklahoma City	18	3	0	1	May 68	5	82	5	82	0
	Ponca City	21	6	1	3	Nov 68	2	76	2	76	0
Ore:	Portland	12	1	0	0	Aug 68	6	32	6	32	0
Pa:	Harrisburg	16	3	0	1	Aug 68	(c)				
P.R:	San Juan	(b)				Dec 68	(c)				
R.I:	Providence	17	6	0	1	May 68	2	40	2	40	10
S.C:	Columbia	18	3	0	1	Apr 68	3	35	3	35	5
S. Dak:	Pierre	10	8	1	5	Dec 68	(c)				
Tenn:	Nashville	15	3	0	1	May 68	7	55	7	55	6
Tex:	Austin	7	5	0	3	Sept 68	3	65	(d)		
	El Paso	19	6	1	3	June 68	(c)				
Utah:	Salt Lake City	30	3	0	1	July 68	1	10	1	10	6
Vt:	Barre	15	3	0	2	Oct 68	4	51	4	51	2
Va:	Richmond	15	1	0	0	Oct 68	2	32	2	32	22
Wash:	Seattle	22	0	0	0	Oct 68	7	33	(d)		
	Spokane	20	3	0	2	Sept 68	2	8	2	8	3
W. Va:	Charleston	17	2	0	1	Apr 68	6	52	5	44	8
Wisc:	Madison	19	1	0	1	Oct 68	10	182	10	182	85
Wyo:	Cheyenne	20	7	1	4	Nov 68	1	2	1	2	11
Network summary		1,175	12	0	2		5	62	5	63	24

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] Indicates no report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

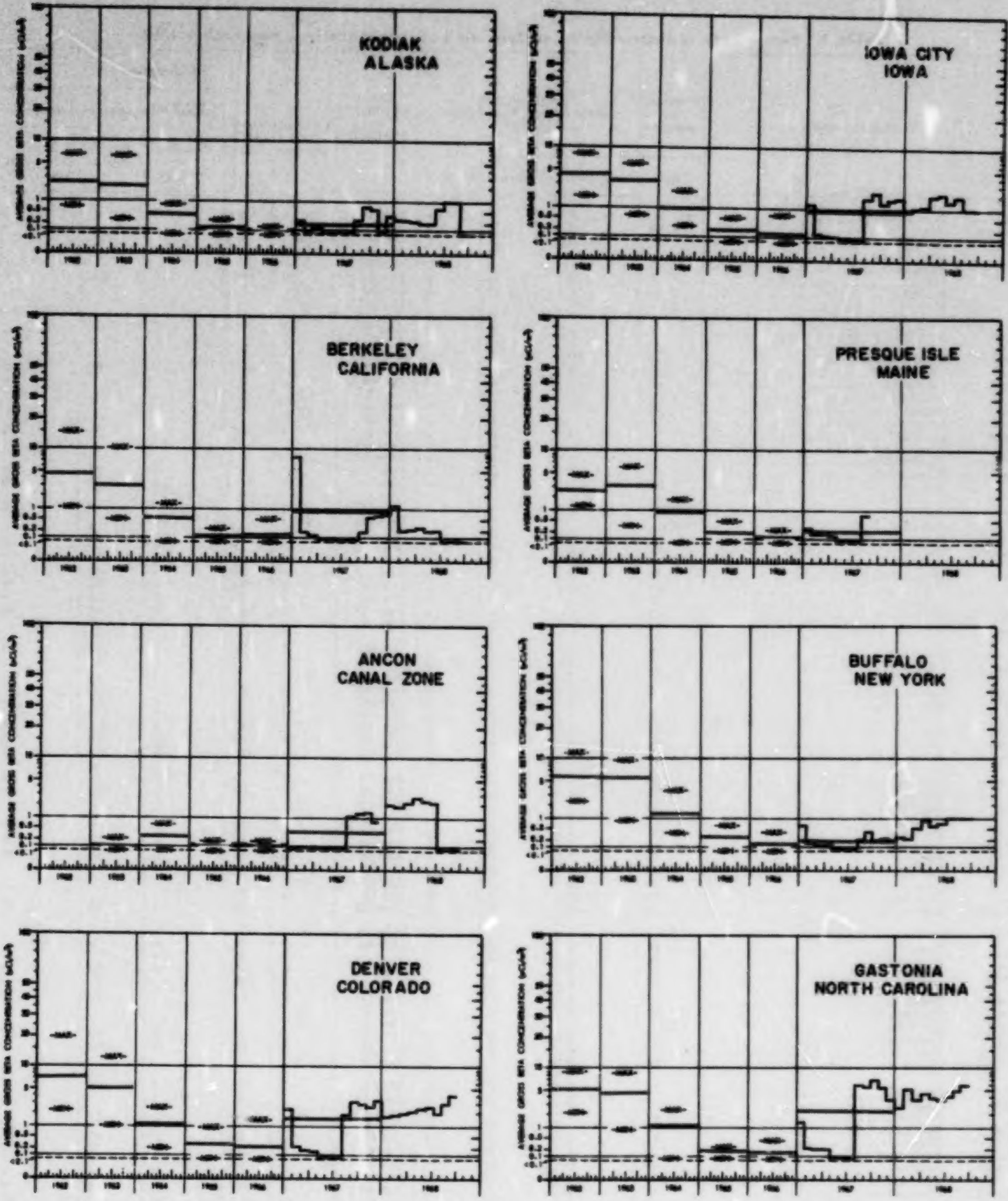

Figure 2. Monthly and yearly profiles of beta radioactivity in air — Radiation Alert Network, 1962-September 1968

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2. Canadian Air and Precipitation Monitoring Program, September 1968

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the April 1968 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for September 1968 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, September 1968

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	30	0.3	0.0	0.1	NS	NS
Coral Harbour	14	.1	.0	.0	27	2.1
Edmonton	30	.1	.0	.1	34	1.3
Ft. Churchill	30	.1	.0	.0	15	1.0
Ft. William	30	.2	.0	.1	37	1.7
Fredericton	30	.2	.0	.1	27	1.2
Goose Bay	30	.2	.0	.1	22	2.8
Halifax	29	.3	.0	.1	42	1.5
Inuvik	30	.1	.0	.0	122	.7
Montreal	25	.3	.0	.1	12	.7
Moosonee	30	.2	.0	.1	11	.5
Ottawa	30	.2	.0	.1	17	1.4
Quebec	30	.2	.0	.1	27	1.9
Regina	23	.1	.0	.1	54	1.8
Resolute	24	.1	.0	.1	34	.2
St. John's, Nfld.	30	.1	.0	.1	33	1.0
Saskatoon	30	.2	.0	.1	34	1.2
Sault Ste. Marie	28	.2	.0	.1	25	2.9
Toronto	30	.2	.0	.1	20	1.6
Vancouver	30	.1	.0	.0	30	2.6
Whitehorse	30	.1	.0	.0	16	1.0
Windsor	30	.2	.0	.1	34	1.5
Winnipeg	30	.2	.0	.1	33	2.0
Yellowknife	30	.1	.0	.0	54	3.3
Network summary	690	0.3	0.0	0.1	34	1.6

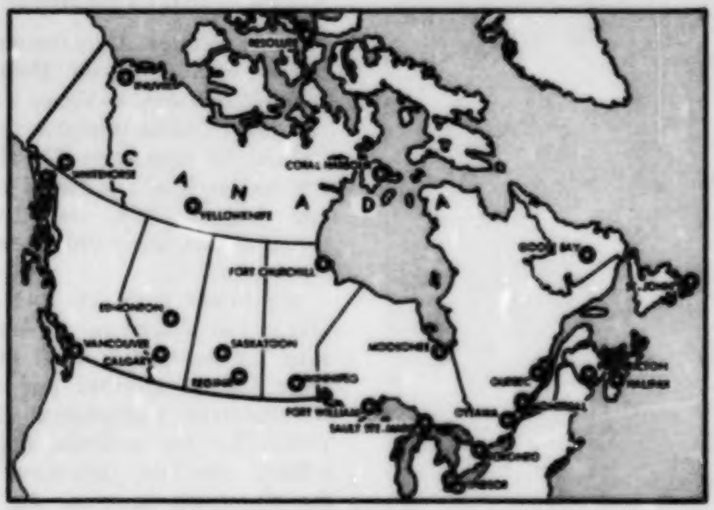
RESOLUTE
INUVIK
WHITEHORSE
C A N A D A
YELLOWKNIFE
CORAL HARBOUR
FORT CHURCHILL
GOOSE BAY
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
FREDERICTON
HALIFAX
QUEBEC
MONTREAL
OTTAWA
FORT WILLIAM
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data in the October 1968 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Air Sampling Program September 1968

Pan American Health Organization and U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling locations are shown in figure 4. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports*. The September 1968 air monitoring results from the participating countries are given in table 3. The average concentration of gross beta radioactivity in all of the countries has decreased from the levels observed in August, but remain somewhat above pre-August levels.

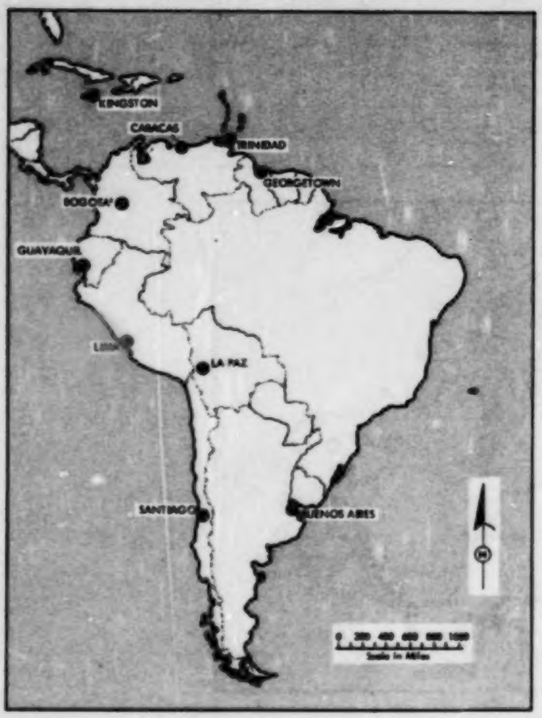

Figure 4. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, September 1968

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average[a]
Argentina:				
Buenos Aires	NS			
Bolivia:				
La Paz	21	8.33	1.23	2.75
Chile:				
Santiago	29	2.02	.09	.63
Colombia:				
Bogota	16	.27	.02	.13
Ecuador:				
Guayaquil	18	1.57	.45	.78
Guyana:				
Georgetown	NS			
Jamaica:				
Kingston	18	.17	.04	.07
Peru:				
Lima	18	2.50	.57	1.30
Venezuela:				
Caracas	19	.92	.02	.26
West Indies:				
Trinidad	18	.51	.03	.23
Pan American summary	157	8.33	0.02	0.82

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

NS, no samples received.

4. Plutonium in Airborne Particulates and Precipitation, January–March 1968

Bureau of Radiological Health U.S. Public Health Service

The Radiation Alert Network (RAN) of the Bureau of Radiological Health, Public Health Service, routinely analyzes airborne particulate and precipitation samples from selected RAN stations for plutonium. The airborne particulate and analyses was initiated in November 1965 and August 1966, respectively. The results through December 1967 have been previously reported (*7–14*).

Air filters from 11 RAN stations are analyzed for plutonium. A monthly composite is made of one-half of each individual air filter from the 11 stations and sent to the PHS Northeastern Radiological Health Laboratory (NERHL) for analysis. Eight RAN stations submit complete collections of precipitation for plutonium analysis. An 8-liter (or whatever is available) aliquot of the monthly collection of each of the 8 stations is forwarded

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Table 5. Plutonium in airborne particulates, January–March 1968

	Buffalo	Gastonia	Rockville	Pierre	New Orleans	Austin	Denver	Anchorage	Phoenix	Honolulu	Seattle
Plutonium-238 (fCi/m³)											
January	0.0049	0.0093	NS	0.0058	0.0131	0.0069	0.0124	0.0062	0.0117	0.0061	0.0068
February	.0082	.0138	NS	.0057	.0116	.0074	.0096	.0068	.0139	.0063	.0082
March	.0074	.0138	NS	.0104	.0102	.0108	.0086	.0018	.0117	.0068	.0151
Plutonium-239 (fCi/m³)											
January	.0136	.0155	NS	.0119	.0140	.0190	.0255	.0092	.0262	.0136	.0074
February	.0122	.0270	NS	.0199	.0276	.0138	.0236	.0143	.0359	.0148	.0245
March	.0282	.0307	NS	.0371	.0423	.0386	.0503	.0063	.0448	.0185	.0203
Plutonium-239/plutonium-238											
January	2.78	1.67	NS	2.05	1.07	2.75	2.06	1.48	2.24	2.23	1.09
February	1.48	1.96	NS	3.49	2.38	1.86	2.46	2.10	2.58	2.35	2.99
March	3.81	2.22	NS	3.56	4.14	3.57	5.85	3.50	3.83	2.72	1.34

NS, no sample.

to the NERHL for analysis. The analytical methodology for processing these samples is described in the December 1968 issue of *Radiological Health Data and Reports* (*14*).

The results for January through March 1968 are presented in tables 5 and 6. ND (not detectable) has been used to indicate samples containing plutonium-238 or plutonium-239 activities less than or equal to the appropriate minimum detectable activities (0.020 pCi and 0.015 pCi per sample for plutonium-238 and plutonium-239, respectively). Sample size varies, generally ranging from 20,000 to 30,000 cubic meters of air for the air filter samples, and from 2 to 8 liters for the precipitation samples.

The data for plutonium-238 in precipitation have not been included in table 6 since the majority of the analyses produced results less than the minimum detectable concentration. The only exceptions were the February samples for Austin, Tex., and Honolulu, Hawaii, as follows:

	Depth (mm)	Concentration (pCi/liter)	Deposition (pCi/m²)
Austin	43	0.0039	0.17
Honolulu	22	0.0217	0.48

Table 6. Plutonium-239 in precipitation, January–March 1968[a]

	Gastonia	Rockville	Pierre	New Orleans	Austin	Denver	Honolulu	Seattle
Precipitation depth (mm)								
January	47	61	NS	6	118	12	115	115
February	14	NS	NS	35	43	9	22	89
March	50	89	NS	52	61	13	35	105
Concentration (pCi/liter)								
January	ND	.0037	—	ND	.0034	NA	ND	.0036
February	.0188	—	—	.0062	.0096	ND	.0073	.0069
March	ND	.0162	—	.0061	ND	.0624	ND	.0115
Deposition (pCi/m²)								
January	—	0.23	—	—	0.40	—	—	.41
February	.26	—	—	0.22	0.41	—	.16	.61
March	—	1.44	—	0.32	—	—	—	1.21

[a] The basic finding is the concentration (pCi/liter). This figure is multiplied by the depth of precipitation for the month (mm) to obtain the total deposition (pCi/m²). One liter of water is collected when 1 mm of precipitation falls on 1-square meter.
NA, no analysis.
ND, nondetectable.
NS, no sample.

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REFERENCES

(1) PUBLIC HEALTH SERVICE. Environmental Radiation Surveillance Report. Bureau of Radiological Health, Standards and Intelligence Branch, Rockville, Md. 20852 (Distribution by official request).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(3) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(4) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(5) BEALE, J. and J. GORDON. The operation of the Radiation Protective Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(6) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

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(9) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates, July–September 1966. Radiol Health Data Rep 8:108–109 (February 1967).

(10) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates, October–December 1966. Radiol Health Data Rep 8:238–239 (May 1967).

(11) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates, January–March 1967. Radiol Health Data Rep 8:534 (September 1967).

(12) LEVINE, H., W. P. KIRK, H. J. L. RECHEN. Plutonium and strontium–90 in precipitation, August 1966 through March 1967. Radiol Health Data Rep 8:574–576 (October 1967).

(13) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates and precipitation and strontium–90 in precipitation, April–June 1967. Radiol Health Data Rep 8:662–663 (November 1967).

(14) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates and precipitation, July–December 1967. Radiol Health Data Rep 9:761–763 (December 1968).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Portsmouth Area Gaseous Diffusion Plant and the Savannah River Plant.

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[1] Title 10, Code of Federal Regulations, Part 20. "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

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1. Portsmouth Area Gaseous Diffusion Plant [2] January–June 1968

Goodyear Atomic Corporation
Piketon, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium-234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. To verify the effectiveness of plant controls, environmental monitoring is conducted for evidence of alpha particle, beta particle, and gamma-ray emitters.

Air samples are generally collected monthly at 21 sites located from 1 to 6 miles from the plant as shown in figure 1. Monthly water samples are collected at 13 stations within 5 miles of the plant.

For January–June 1968, the waterborne beta-gamma radioactivity, airborne alpha and beta-gamma radioactivity and the background exposure remained essentially unchanged compared with the 1967 results. The waterborne alpha radioactivity increased slightly for January–June 1968. However, the overall results for alpha radioactivity in water equaled only 0.13 percent of the AEC concentration standards.

Average background dose rates remained unchanged from the first half 1967 values. In the calculations it is assumed that all of the dose rates are attributable to plant operations. As in the past, the offsite and onsite patterns are very much alike in form and intensity with no significant differences between the average values. From the onsite and offsite intensities, it is evident that the plant operations have not added appreciably to the general background radiation.

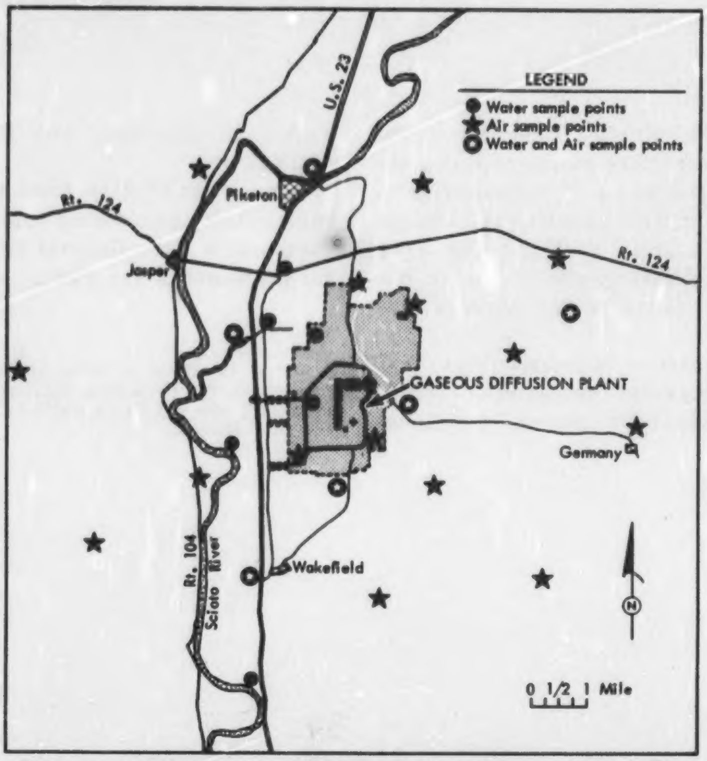

Figure 1. Sampling locations, Portsmouth Area Gaseous Diffusion Plant

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[2] Data summarized from B. Kalman and S. H. Hulett, "Environmental Radiation Levels and Concentrations, First Half 1968" (August 19, 1968).

Average alpha and beta-gamma radioactivity concentrations in air and water are summarized in table 1. The external gamma-ray levels, measured at the air sampling locations shown in figure 1, are also summarized in table 1. The overall average concentrations and background exposure rates for 1967 and January–June 1968 are presented in table 2 as percent of standards.

Table 1. Environmental radioactivity, Portsmouth Plant, January–June 1968

Type of monitoring	Number of samples	Maximum	Minimum	Average	Average as a percent of AEC standard[a]
Air:					
Alpha radioactivity, pCi/m^3	126	0.4	<0.1	<0.1	<5.0
Beta-gamma radioactivity, pCi/m^3	126	2.5	<0.1	.2	.02
Water:					
Alpha radioactivity, pCi/liter	54	1080	<0.5	26.3	.13
Beta-gamma radioactivity, pCi/liter	54	1440	<14.0	53.9	.27
Background dose rates[b], mrad/hr.	126	.022	.009	.014	16.8

[a] The applicable AEC radiation protection standards are as follows:

Air (alpha radioactivity)	2 pCi/m^3
Air (beta-gamma radioactivity)	1 x 10^3 pCi/m^3
Water (alpha radioactivity)	2 x 10^4 pCi/liter
Water (beta-gamma radioactivity)	2 x 10^4 pCi/liter
External beta-gamma radioactivity	0.5 rem/yr (approx. 0.6 mrad/hr)

[b] Measurements were made with an open-shield Geiger-Mueller tube 1 foot above ground. The 3-foot rate (not shown) was experimentally determined to average two-thirds of the 1-foot rate and was used to determine the percent of the AEC standard.

Table 2. Comparison of average concentrations Portsmouth Plant, 1967 and 1968

Type of monitoring	Percent of AEC standard[a]			
	1967			1968
	First half	Second half	Calendar year	First half
Air				
Alpha radioactivity	<5.0	.23	<5.0	<5.0
Beta-gamma radioactivity	.02	.01	.01	.02
Water				
Alpha radioactivity	.09	.08	.08	.13
Beta-gamma radioactivity	.20	.28	.24	.27
Background exposure extrapolated to 3 feet above ground level	16.8	17.9	17.3	16.8

[a] See footnote (a) of table 1.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1967	January 1968
July–December 1967	July 1968

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2. Savannah River Plant [3]
January–June 1968

E. I. duPont de Nemours
Aiken, South Carolina

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E. I. duPont de Nemours and Company, occupies an area of 312-square miles along the Savannah River, 22-miles downstream from Augusta, Ga. Production facilities include a fuel preparation area, three reactors, two fuel separation areas, and a heavy water production plant. A basic goal in plant operation is total containment of radioactive waste. Although some very low-level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to ensure environmental concentrations below recommended guides.

The DuPont environmental monitoring group has maintained a continuous monitoring program since 1951 (before plant startup) to determine the concentrations of radioactive materials in a 1,200-square mile area outside the plant. Included in this area are parts of Aiken, Barnwell, and Allendale counties in South Carolina, and Richmond, Burke, and Screven counties in Georgia. This surveillance determines the magnitude and origin of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk, are compared with the maximum permissible concentrations (MPC) recommended by the International Commission on Radiological Protection (ICRP), or the daily intake guides recommended by the Federal Radiation Council (FRC).

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[3] Summarized from "Effect of the Savannah River Plant on Environmental Radioactivity, Semiannual Report, January–June 1968" (DPST 68-30-2).

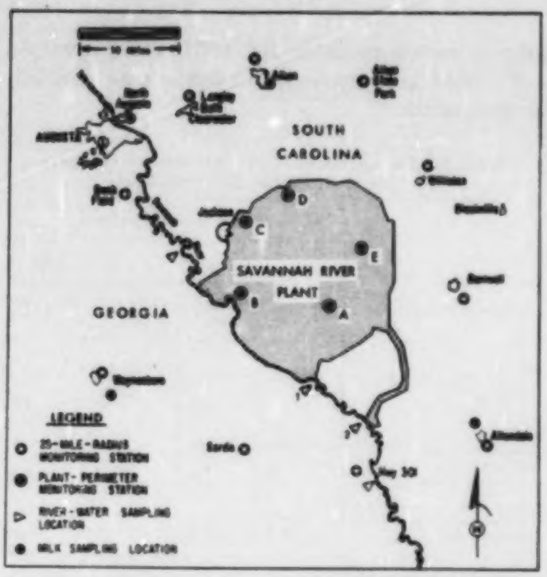
SOUTH CAROLINA
GEORGIA
AUGUSTA
Jackson
SAVANNAH RIVER PLANT
A
B
C
D
E
1
2
Sardis
Hwy 301
LEGEND
25-MILE-RADIUS MONITORING STATION
PLANT-PERIMETER MONITORING STATION
RIVER-WATER SAMPLING LOCATION
MILK SAMPLING LOCATION

Figure 2. Environmental sampling locations, Savannah River Plant

Sensitive instruments, which can detect traces of radioactive materials far below concentrations of hazard significance, are used to determine radioactivity in the environs. Plant-released radioactivity and atmospheric fallout are included in the reported concentrations. Maximum and minimum values given are for individual samples collected during the report period.

Atmospheric monitoring

Concentrations of radioactive materials in the atmosphere were measured by biweekly analyses of air filters collected at five monitoring stations near the plant perimeter and 10 stations around a circle of about 25-mile radius from the center of the plant (figure 2). Deposition rates of radioactive material at each station were also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). The monitoring stations are spaced so that a significant release of airborne radioactivity by the Savannah plant would be detected regardless of the prevailing wind. All stations operate continuously. Four additional monitoring stations at Savannah and Macon, Ga., and at Columbia and Greenville, S. C., are so distant from the plant that the effect of Savannah River Plant operations is negligible; they are reference points for determining background radioactivity levels (figure 3). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between weapons test fallout and Savannah River Plant releases.

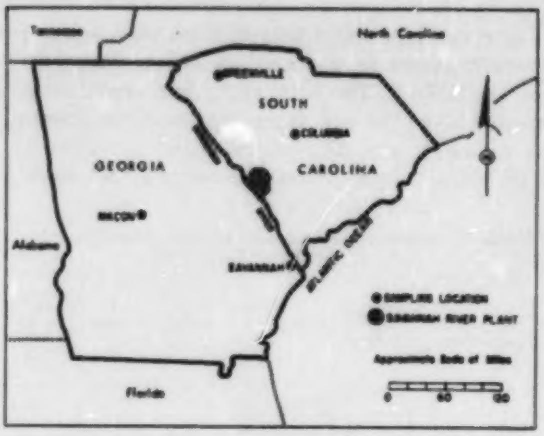
Tennessee
North Carolina
GREENVILLE
SOUTH CAROLINA
COLUMBIA
GEORGIA
MACON
Alabama
SAVANNAH
ATLANTIC OCEAN
Florida
SAMPLING LOCATION
SAVANNAH RIVER PLANT
Approximate Scale of Miles
0
60
120

Figure 3. Distant air monitoring stations, Savannah River Plant

The small amount of filterable beta radioactivity released to the atmosphere, primarily from fuel separation areas, was obscured by fallout. The influence of the weapons tests which resumed in September 1961 is shown in figure 4. The rise in early 1964 was the result of the anticipated spring increase in the mixing of the stratospheric debris into the troposphere. The average beta radioactivity concentration in air increased from 0.03 to 0.15 pCi/m^3 during January–June 1968.

Radioactivity in air, determined from filter analyses, is shown in table 3. The January–June 1968 concentrations of filterable beta radioactivity (0.15 pCi/m^3) and alpha radioactivity (0.0008 pCi/m^3) in air were 0.15 and 1.1 percent of the respective MPC's. Tritium oxide concentrations in air, at the plant perimeter and at the 25-mile stations, did not exceed 0.1 percent of the MPC.

Deposition of fallout during January–June 1968 totaled 21 nCi/m^2 at the plant perimeter locations and 17 nCi/m^2 at 25-mile radius locations; comparable values for the last half of 1967 were 1.2 and 1.0 nCi/m^2. Deposition at each sampling location is presented in table 4.

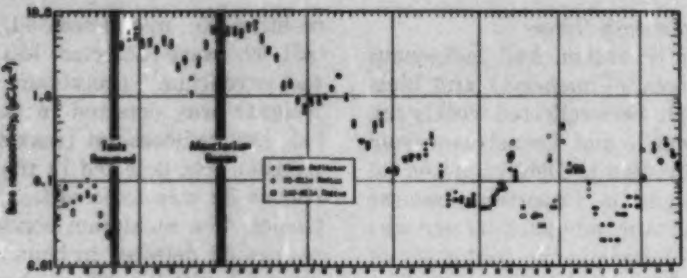

Figure 4. Influence of weapons tests

Table 3. Radioactivity in air, Savannah River Plant, January–June 1968

Filter analysis	Average concentrations (pCi/m³)																
	Plant perimeter locations						25-mile radius locations										
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Alpha particle emitters[a] (multiply by 10⁻³)																	
Maximum	1.5	1.7	1.4	1.2	1.2		1.8	2.3	2.1	2.2	1.8	1.5	2.2	2.5	1.9	2.6	
Minimum	ND	ND	.4	ND	.4		.3	.3	.6	ND	ND	.3	.3	.4	.6	.4	
Average	.9	.9	.9	.8	.7	0.8	.9	.9	1.0	.8	.8	.9	.8	.8	.9	.9	0.9
Nonvolatile beta-particle emitters[b]																	
Maximum	.35	.27	.30	.34	.31		.35	.42	.28	.28	.31	.36	.27	.31	.30	.29	
Minimum	.06	.08	.06	.09	.07		.06	.09	.08	.06	.05	.06	.06	.07	.08	.09	
Average	.21	.18	.19	.19	.20	0.19	.20	.21	.19	.18	.19	.20	.18	.19	.19	.19	0.19
	Composite sample						Composite sample										
Specific radionuclides (averages)																	
Strontium-89, -90	0.01						0.01										
Cesium-137	.01						.01										
Cerium-141, -144	.06						.05										
Zirconium-niobium-95	.08						.08										
Ruthenium-103, -106	.05						.09										
Manganese-54	.01						.01										
Beryllium-7	.14						.15										

[a] Sensitivity of analysis—3.0 x 10⁻⁴ pCi/m³; ICRP Maximum Permissible Concentration: 0.07 pCi/m³.
[b] Sensitivity of analysis—0.006 pCi/m³; ICRP Maximum Permissible Concentration: 100 pCi/m³.
ND, nondetectable, less than sensitivity of analysis.

Table 4. Total fallout deposited, Savannah River Plant, January–June 1968

Radionuclide	Deposition (nCi/m²)																
	Plant perimeter locations						25 mile radius locations										
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Alpha[a]	7.3	9.6	8.1	17.9	19.3	12.0	9.2	5.2	15.7	5.8	5.7	16.0	3.1	13.8	9.0	13.5	9.7
Strontium-89	1.0	.3	ND	.8	.3	.5	.6	.7	1.2	.7	.3	.3	.5	.4	.3	.1	.5
Strontium-90	.6	.8	.8	.9	.7	.8	1.2	.8	.7	.9	1.0	1.1	.7	.9	1.1	1.0	.9
Cesium-137	1.1	1.9	1.3	1.4	1.6	1.5	1.5	1.5	1.0	1.3	2.3	2.2	1.5	1.6	1.3	1.8	1.6
Cerium-141, -144	6.8	5.9	9.2	5.2	6.1	6.6	10.3	4.2	5.6	8.2	8.0	6.9	4.6	2.9	6.1	6.7	6.4
Zirconium-niobium-95	9.1	7.7	11.3	6.6	9.0	8.7	14.1	4.4	6.9	12.8	13.6	10.4	7.3	4.7	9.3	10.4	9.5
Beryllium-7	34.6	30.6	47.4	32.2	38.4	35.8	22.8	11.6	31.0	30.9	37.1	36.0	11.8	22.2	18.5	28.8	25.1
Ruthenium-106	ND	ND	2.1	ND	1.1	0.6	2.8	ND	ND	1.6	2.0	ND	1.7	ND	ND	ND	.8

[a] Multiply by 10⁻³.
ND, nondetectable, less than sensitivity of analysis.

Algae and fish in Savannah River

Fish, predominantly bream, and indigenous algae, primarily green *(Vaucheria)* and blue-green *(Phormidium)*, were collected weekly upstream from, adjacent to and downstream from the Savannah River Plant. Determination of radionuclides in algae is important because algae concentrate certain radionuclides and also because of the role of algae in the food chain of aquatic organisms. Beta-particle concentrations in algae and fish adjacent to and downstream from SRP indicate some minor contribution by SRP. Although measurably higher than similar material collected at the control station 3-miles upstream from the Savannah River Plant, the slight increase is of no biological significance.

Specific radionuclide analyses were made on algae and fish collected from the Savannah River. Radiocesium and radiostrontium were found consistently in river algae; whereas, cerium–141,–144, chromium–51, zirconium-niobium–95, manganese–54, zinc–65, and cobalt–60, were detected less frequently. Also, radiostrontium (maximum, 18 pCi/g, wet weight) was detected in bone tissue of river fish, and radiocesium (maximum 31 pCi/g, wet weight) was detected in the flesh tissue. Phosphorus–32 was detected less frequently in these tissues. The maximum concentrations of phosphorus–32 detected in bone and flesh tissues of river fish was 36 pCi/g; phosphorus–32 in flesh tissue was less than the sensitivity of analysis (2 pCi/g).

Water monitoring

The plant site is drained by five streams that flow several miles through the reservation before reaching the river (figure 5). In January 1965, the Beaufort-Jasper Water Authority began operation of a new treatment facility to furnish drinking water, partially supplied from the Savannah River, to most of Beaufort

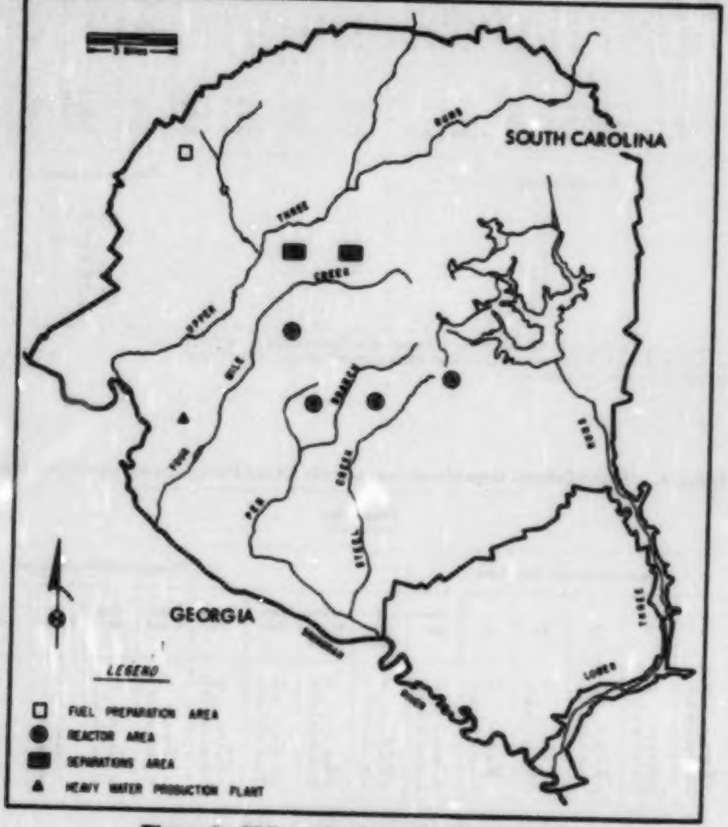

Figure 5. SRP production and effluent steams

County, South Carolina. Water is supplied through a new canal from the river at a location about 90 miles below the Savannah River Plant. The city of Savannah also supplements its domestic well water supply with river water during periods of peak demand.

Communities near the plant get domestic water from deep wells or surface streams. Public water supplies from 14 surrounding towns were collected and analyzed in April. There was no evidence that SRP contributed radioactivity to drinking water supplies; concentrations of alpha radioactivity (1.0 pCi/liter) and beta radioactivity (6 pCi/liter) were essentially the same as those observed before plant startup.

River water, analyzed weekly, was sampled continuously at four locations, as shown in figure 5. Average concentrations of specific radionuclides found in river water during January–June 1968 appear in table 5.

Table 5. Average concentration of radionuclides in Savannah River water, January–June 1968

Radionuclide	Concentration (pCi/liter)			
	Sensitivity of analysis	Control (3 miles upstream from plant)	Highway 301 (10 miles downstream from plant)	Percent MPC at Highway 301
Tritium	600	800	9,500	0.31
Ruthenium-103, -106	3.2	ND	ND	< .03
Cerium-141, -144	2.5	ND	ND	< .02
Cesium-134, -137	.6	ND	.9	.004
Neptunium-239	2.2	ND	ND	< .002
Barium-lanthanum-140	1.6	ND	ND	< .01
Zirconium-niobium-95	.5	ND	ND	< .001
Chromium-51	4.3	ND	11.8	.0006
Strontium-89	.3	ND	2.6	.09
Iodine-131	.5	ND	ND	.16
Strontium-90	.01	.6	1.0	.25
Cobalt-60	1.4	ND	ND	< .003
Zinc-65	1.1	ND	ND	< .001
Manganese-54	.4	ND	ND	< .0034
Sulfur-35	10.0	ND	32	.05

ND, nondetectable, less than sensitivity of analysis.

Tritium, sulfur–35, and trace amounts of cesium–137, chromium–51, strontium–89, and strontium–90, released mainly from reactor areas, were the radionuclides of SRP origin detectable in river water at the downstream location. Strontium–90 and tritium from worldwide fallout were also detected in river water upstream from the Savannah plant. The tritium concentrations in raw water collected from the Beaufort-Jasper Water Plant averaged 5,000 pCi/liter (0.2 percent of the MPC) during the 6-month report period. The annual radiation dose of an individual in this population from the consumption of water containing the very low concentration of tritium is only 0.4 mrem. The radiation dose was determined by analysis of urine (38 samples) collected from Beaufort residents during January–June 1968.

Tritium, a beta-particle emitter and the most abundant radionuclide released to the river, is produced by neutron irradiation of heavy-water moderator in the reactors. Sulfur–35, also a beta-particle emitter and the second most abundant radionuclide released to the river, is produced by neutron irradiation of stable sulfur (a component of the ion exchange resin used in the moderator-purification system in reactor areas). The tritium and sulfur–35 concentrations in river water averaged 0.31 and 0.05 percent of the MPC, respectively.

Vegetation

Radioactive contamination of growing plants may result from deposition on foliar surfaces or absorption of radioactive materials from the soil.

Grass samples were collected at seven locations along the plant perimeter and at seven other locations along a 25-mile radius route. (These are not designated on figure 2). Samples from each quadrant of the plant site and of the surrounding area were composited for monthly analysis. Radionuclides in grass samples were from fallout. Alpha-particle emitters averaged 0.2 pCi/g at the plant perimeter and 25-mile radius locations as compared to 0.1 pCi/g during the last half of 1967; gamma-ray emitters averaged 21 and 31 pCi/g, respectively, as compared to 4.8 and 5.3 pCi/g for the last half of 1967.

Milk

Milk was sampled at three dairies within a 25-mile radius of the Savannah River Plant, as shown in figure 2. Samples which were collected biweekly were analyzed for tritium and radioiodine. Strontium–90 determinations were made quarterly. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from analyzing milk for radioactivity during January–June 1968 are shown in table 6.

Table 6. Radioactivity in milk from local dairies Savannah River Plant, January–June 1968

Distributing points	Concentration (pCi/liter)							
	Tritium[a]			Strontium-90[b]		Iodine-131[c]		
	Maximum	Minimum	Average	March	June	Maximum	Minimum	Average
Aiken	3,000	ND	ND	15	23	ND	ND	ND
North Augusta	9,000	ND	ND	15	25	ND	ND	ND
Waynesboro	5,000	ND	ND	10	NS	ND	ND	ND
Major distributors[d]	3,000	ND	ND	15	15	ND	ND	ND

[a] Sensitivity of analysis—3,000 pCi/liter.
[b] Sensitivity of analysis—1.0 pCi/liter.
[c] Sensitivity of analysis—5.0 pCi/liter.
[d] Milk produced in local dairies, but sold by major distributors.
ND, nondetectable, less than sensitivity of analysis.

Average concentrations of the radionuclides in milk (17 pCi/liter for strontium–90 and <5 pCi/liter for iodine–131, compared to 12 and <5 pCi/liter, respectively, during the last half of 1967) were consistent with values reported by the U.S. Public Health Service for most sections of the United States. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level was less than the sensitivity of the analysis, which allows detection of concentrations of 3,000 pCi/liter (<0.1 percent of the MPC for water).

Environmental gamma radiation levels

Monthly measurements of environmental gamma radiation were made with thermoluminescent dosimeters. The January–June 1968 data (shown in table 7), are characteristic of measurements observed at individual stations for the past several years.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1967	February 1968
July–December 1967	June 1968

Table 7. Environmental gamma radiation, Savannah River Plant, January–June 1968

Filter Analysis	Exposure (mR/day)																
	Plant perimeter locations						25-mile radius locations										
	A	B	C	D	E	Average	Aiken Airport	Aiken State	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Hwy 301	Average
Maximum	0.29	0.29	0.28	0.24	0.50		0.71	0.33	0.23	0.23	0.43	0.44	0.29	0.39	0.31	0.28	
Minimum	.07	.07	.07	.06	.07		.03	.06	.09	.06	.03	.07	.04	.09	.07	.07	
Average	.19	.18	.19	.16	.21	0.19	.25	.18	.16	.18	.21	.20	.12	.19	.20	.18	0.19

Erratum

The June 1968 data for the Mexican Air Monitoring Network presented in the October 1968 issue of *Radiological Health Data and Reports*, pp. 575–576, is incorrect. The correct data will be presented in the February 1969 issue.

Reported Nuclear Detonations, December 1968

The U.S. Atomic Energy Commission announced three underground nuclear tests for the month of December 1968.

On December 8, 1968, the Atomic Energy Commission conducted a nuclear cratering experiment at its Nevada Test Site. The experiment was part of the Commission's Plowshare program to develop peaceful uses of nuclear explosives.

The experiment consisted of the detonation of a minimum-fission nuclear explosive with a yield of about 35 kilotons (equivalent to 35,000 tons of TNT). The explosion took place at a depth of 350 feet underground in hard rock and preliminary estimates indicated that it resulted in a crater with a diameter of about 850 feet and a depth of about 200 feet.

The experiment, called Project Schooner was part of the AEC's program to develop nuclear excavation technology and will provide information about cratering effects in hard rock.

December 12, 1968 a nuclear test of low yield (less than 20 kilotons TNT equivalent) was conducted underground at the Nevada Test Site.

The U.S. Atomic Energy Commission announced that they conducted a nuclear test of about a megaton in yield on December 19, 1968.

Detection of a Soviet nuclear test was announced by the U.S. Atomic Energy Commission on December 18, 1968. Seismic signals originating from the Soviet nuclear test area in the Semipalatinsk region were recorded. The signals were equivalent to those of a nuclear test in the low yield range (less than 20 kilotons TNT equivalent).

Also, on December 27, 1968, the Atomic Energy Commission detected a nuclear explosion in the general area of the Chinese nuclear test site at Lop Nor. Preliminary estimates indicated a yield of approximately 3 megatons TNT equivalent.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

RADIATION DOSES TO CHILDREN'S THYROIDS FROM IODINE–131 IN MILK. *Robert N. Neill and Paul B. Robinson. Radiological Health Data and Reports, Vol. 10, January 1969*, pp. 1–9.

Measurements of idoine–131 in milk taken since 1957 were used to estimate the average cumulative radiation doses to children born and living in selected U.S. cities. The cumulative doses were summed for a cohort (born in a particular year and city) from quarterly doses calculated by varying thyroid weight, uptake factor, and milk consumption, as a function of the age of the child and concentrations of iodine–131 in milk as a function of time and location. Average values of these variables were selected for each quarter.

For a given concentration of iodine–131 in milk, the population receiving the greatest dose are milk-drinking infants of 6 to 11 months of age. Considerable variation was found to exist in cumulative doses for children raised in different cities. Within a particular city, there is a large variation in thyroidal doses for children born in different years.

The largest doses were 1,750 mrem and 1,625 mrem, received by children born in 1957 in St. Louis and Salt Lake City. At the time of the cessation of weapons testing in 1963, the average child of 6 years of age in four of the five U.S. cities where data are available had received man-made cumulative thyroidal doses greater than his cumulative natural dose. Because of the relative absence of iodine–131 in the environment for the past 4 years, the children of today whose cumulative fallout exposure exceed their natural background exposure are those born in 1957 in Cincinnati, Salt Lake City and St. Louis. From the results obtained from these three out of five cities for which data are available, it is apparent that children born in 1957 in Cincinnati, Salt Lake City, and St. Louis, and possibly in some other unmonitored areas of the United States, have cumulative thyroidal doses from iodine–131 following atmospheric weapons tests greater than their cumulative natural background doses, but less than the cumulative dose at an annual dose rate equal to the Radiation Protection Guide (RPG) during the same period.

KEYWORDS: children, doses, idoine–131, milk, thyroids, United States.

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RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 2, February 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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CONSUMER PROTECTION AND ENVIRONMENTAL HEALTH SERVICE
Environmental Control Administration
Bureau of Radiological Health

Reports

Plutonium-239 in Human Tissues and Bone

Paul J. Magno, Peter E. Kauffman and *Paul R. Groulx* [1]

An average concentration of $7\times10^{-11}\mu$Ci ^{239}Pu/g was found in human bone samples ranging in age from 2 to 24 years. This concentration results in an average dose equivalent rate to bone of about 0.3×10^{-4} rem/year. An average concentration of $7\times10^{-10}\mu$Ci ^{239}Pu/g found in liver samples from older adults results in an average dose equivalent rate of about 7×10^{-4} rem/year. These figures were compared to the Federal Radiation Council's Radiation Protection Guides and the dose limits recommended by the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection. From the data in this report, it was concluded that the concentrations of plutonium-239 in body tissue result in average equivalent dose rates well below the suggested radiation protection guides and dose limits.

Radioisotopes of plutonium have been introduced into the environment during nuclear weapons testing and also from the burnup of a satellite which used plutonium as a power source (*1, 2*). The Bureau of Radiological Health initiated a program in July 1965 at the Northeastern Radiological Health Laboratory (NERHL) to determine the environmental concentrations of plutonium. The results of measurements of the radioisotopes of plutonium in air, milk, and total diet, have been previously reported (*3–5*); the concentrations of plutonium-239 in human tissues and bone are presented in this report.

Analytical methodology

Soft tissue samples were solubilized by wet ash with a mixture of nitric and perchloric acids. Plutonium-236 tracer was added, the plutonium was reduced to the +3 oxidation state with hydroxylamine hydrochloride and coprecipitated with the alkaline earth phosphates by addition of ammonium hydroxide. The alkaline earth phosphate precipitate was dissolved in 7.2 $\underline{M}$ nitric acid and the plutonium oxidized to the +4 oxidation state with sodium nitrite. Bone samples were solubilized by ashing at 800°C., plutonium-236 tracer was added and the ash dissolved in 7.2 $\underline{M}$ nitric acid.

The nitric acid solution of each sample was then passed over an anion exchange resin in the nitrate form. The resin was washed with additional 7.2 $\underline{M}$ nitric acid and then with 9 $\underline{M}$ hydrochloric acid. The plutonium was eluted from the resin with a mixture of 0.36 $\underline{M}$ hydrochloric acid and 0.01 $\underline{M}$ hydrofluoric acid, electroplated onto a stainless steel planchet from a sulfuric acid-ammonium electrolyte, and counted in an alpha-particle spectrometer.

---

[1] Mr. Magno is chief, Environmental Methods and Surveillance Section, Northeastern Radiological Health Laboratory, Bureau of Radiological Health, Winchester, Mass. 01890. Mr. Kauffman was formerly acting chief, Analytical Quality Control Service, NERHL, and is now a research chemist, Food Protection Research Laboratory, Bureau of Community Environmental Management, 222 E. Central Parkway, Cincinnati, Ohio. Mr. Groulx is a physical science technician at the Northeastern Radiological Health Laboratory.

The energies of the alpha particles from plutonium–239 and plutonium–240 are not sufficiently different to be separated by alpha particle spectrometry. Therefore, when plutonium–239 is referred to in this report, it represents the sum of the radioactivity of plutonium–239 and plutonium–240.

The samples were usually counted for at least 1,000 minutes. Reagent blanks containing plutonium–236 tracer were run concurrently with the samples. The alpha radioactivity of plutonium–239 was converted to picocuries of the radioisotope per sample by means of the following equation:

$$^{239}\mathrm{Pu} = \frac{(A-B)C}{(D-E)}$$

where,

A = gross counts per minute (CPM) in plutonium-239 spectral region;
B = reagent blank counts per minute in plutonium-239 spectral region;
C = pCi plutonium-236 added;
D = gross counts per minute in plutonium-236 spectral region; and
E = background counts per minute in plutonium-236 spectral region.

A silicon surface barrier detector with an active area of 4.5 cm^2 was used. With the sample electroplated onto a 3.1 cm^2 area, the counting efficiency for plutonium–239 and plutonium–236 was ~31 percent and the resolution was 75 keV (FWHM)[2].

Results

Table 1 presents the results of the analyses of plutonium–239 in human liver and lung samples obtained from autopsies in the Boston, Mass. area during the period August 1965 to February 1967. The plutonium–239 concentrations in the liver samples ranged from 0.21 to 2.52 pCi/kg with a mean value of 0.76 pCi/kg; the lung concentrations ranged from 0.13 to 1.13 pCi/kg with a mean value of 0.43 pCi/kg. Samples of spleen, heart, kidney, and bone were also obtained during some of these autopsies but plutonium–239 was not detected in any of these organs.

Table 1. Plutonium-239 in human liver and lung samples collected from Boston, Mass.

Subject		Date of death	Plutonium-239 (pCi/kg) [a]	
Age	Sex		Liver	Lung
73	M	8/65	0.25 ±0.04	0.22 ±0.07
66	F	8/65	.36 ± .08	.23 ± .08
58	F	8/65	.37 ± .13	.48 ± .11
52	F	8/65	NS	.74 ± .21
80	F	8/65	2.52 ± .50	1.13 ± .17
47	M	10/65	NS	.14 ± .04
76	F	11/65	.69 ± .10	.34 ± .06
70	F	1/66	.21 ± .04	.17 ± .09
80	M	3/66	.83 ± .13	.45 ± .09
63	M	6/66	.60 ± .11	.33 ± .07
65	M	6/66	1.20 ± .13	.42 ± .09
58	M	6/66	1.31 ± .09	.74 ± .14
54	M	7/66	.31 ± .08	.41 ± .11
59	M	7/66	.63 ± .07	.55 ± .21
83	M	9/66	.86 ± .14	.13 ± .03
63	M	2/67	.45 ± .11	.39 ± .09

[a] Two sigma counting error.
NS, no sample obtained.

Table 2 presents the results of the analyses of plutonium–239 in human liver and lung samples collected from other areas in the United States during the period September 1966 to January 1967. The plutonium–239 concentrations in these liver samples ranged from 0.31 to 1.14 pCi/kg with a mean value of 0.69 pCi/kg; the lung concentrations ranged from 0.17 to 0.94 pCi/kg with a mean value of 0.41 pCi/kg.

Table 2. Plutonium-239 in human liver and lung samples collected from various areas in the United States

Subject		Date of death	Collection location	Plutonium-239 (pCi/kg) [a]	
Age	Sex			Liver	Lung
71	F	9/66	Portland, Ore.	0.31 ±0.08	0.35 ±0.09
54	M	10/66	Indianapolis, Ind.	.52 ± .13	.24 ± .09
72	F	11/66	Colorado Springs, Colo.	.86 ± .17	.94 ± .19
62	F	11/66	Palo Alto, Calif.	.87 ± .11	.17 ± .06
49	M	11/66	Butte, Mont.	1.14 ± .26	.55 ± .12
62	M	1/67	New Orleans, La.	.46 ± .09	.21 ± .08

[a] Two sigma counting error.

Bone samples of sufficient size for detection of plutonium–239 could not be obtained during the autopsies from which the soft tissue samples were collected. Therefore, in order to develop information on the concentrations of plutonium–239 in human bone, a series of composite bone ash samples (vertebrae) containing 150 to 300 grams of ash were analyzed and the results are presented in table 3. These samples were collected during the period, 1964–1966, and were composited according to the area of collection and the age groups used in evaluating the results of analyses of strontium–90 in human bone. (*5*). The concentration of plutonium–239 bones from the 2 to 4-year and 5 to 9-year age groups was higher than that of other age groups.

---

[2] (FWHM), full width at half maximum.

Table 3. Plutonium–239 in human bone composite samples

Age group	Region	Year collected	Plutonium-239 concentration	
			(pCi/kg ash)[a]	(pCi/kg wet bone)[a]
2–4	Central	1964	0.79±0.16	0.080±0.016
	Northeast	1965	.85± .18	.073± .015
5–9	Central	1964	1.4 ± .3	.12 ± .03
	Central	1965	.84± .22	.078± .021
	Northeast	1965	.82± .13	.084± .014
	Northeast	1965	1.1 ± .2	.11 ± .02
	Northeast	1966	1.6 ± .3	.16 ± .03
10–14	Northeast	1965	.44± .11	.046± .012
	Central	1965	.59± .12	.072± .014
15–19	Central	1964	.32± .13	.043± .018
	Central	1965	.27± .09	.039± .013
	Central	1965	.35± .12	.042± .014
	Northeast	1965	.41± .10	.047± .011
	Northeast	1965	.41± .09	.058± .013
	Northeast	1966	.75± .24	.082± .026
20–24	Central	1965	.41± .09	.067± .015
	Central	1965	.40± .10	.064± .016
	Northeast	1965	.41± .11	.050± .014
	Northeast	1965	.55± .13	.072± .017

[a] Two sigma counting error.

One of the objectives of this study was to develop information on the distribution of plutonium in the human body with particular emphasis on the relationship between plutonium–239 in the liver and in the bone. This requires a comparison of data for soft tissue and bone samples from the same individuals. Therefore, liver, lungs, spleens, and large samples of femur were obtained from three cadavers in the Boston, Mass. area. The results of the analyses of these samples are presented in table 4.

Unfortunately, the plutonium–239 concentration in these femurs was below the detection limit and the only observation that can be made from these data concerning the bone-liver relationship is that the concentration of plutonium–239/kg of femur of these individuals was lower than the liver by a factor of at least 10. The availability of bone samples of sufficient size for analysis of plutonium is the limiting factor in using individual autopsies to establish the bone to liver relationship from environmental exposures. Either very large representative bone samples must be obtained (this is very difficult) or more sensitive and sophisticated analytical techniques must be applied.

Table 4. Plutonium–239 in human soft tissue and bone samples collected in Boston, 1963–1965

Subject		Date of death	Organ	Plutonium-239	
Age	Sex			(pCi)	(pCi/kg)[a, b]
75	F	10/63	Liver (whole)	[b] 0.41 ±0.06	0.24 ±0.04
			Spleen (whole)	[c] .010± .011	[c] .067± .073
			Lung (right)	.064± .022	.13 ± .04
			Femur (400 g)	[c] .005± .010	[c] .013± .025
77	F	10/64	Liver (whole)	.77 ± .10	.45 ± .06
			Spleen (whole)	[c] .000± .008	[c] .000± .053
			Lung (right)	.30 ± .05	.60 ± .10
			Femur (455 g)	[c] .008± .010	.018± .022
73	F	10/65	Liver (whole)	.93 ± .12	.55 ± .07
			Spleen (whole)	[c] .007± .010	[c] .049± .065
			Lung (right)	.29 ± .07	.58 ± .14
			Femur (400 g)	[c] .005± .010	[c] .013± .025

[a] Two sigma counting error.

[b] Based on the weight of the organ in standard man except for the femur.

[c] Not significant data but used for averaging purposes.

Conclusions

An average concentration of 7×10^{-11} μCi ^{239}Pu/g was found in bone collected from individuals ranging in age from 2 to 24 years. This concentration[3] results in an average dose equivalent rate to bone of about 3×10^{-4} rem/year. An average concentration of 7×10^{-10} μCi ^{239}Pu/g found in liver samples from older adults results in an average dose equivalent rate of about 7×10^{-4} rem/year. The formula for dose rate calculations for these organs is given in reference (*6*). The Federal Radiation Council (FRC) (*7*) recommends a Radiation Protection Guide for bone of 1.5 rem/year for individuals in the general population and 0.5 rem/year as an average to be applied to suitable samples of an exposed population group. The FRC (*9*) has not recommended a Radiation Protection Guide for liver. The National Council on Radiation Protection and Measurements (*9*) and the International Commission on Radiological Protection (*10*) recommend a dose limit for individual members of the public of 1.5 rem/year for liver.

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[3] Doses were calculated assuming homogeneous distribution of the radionuclide throughout the organ.

From the data presented in this report, it can be concluded that the concentrations of plutonium-239 present in body tissues result in average dose equivalent rates well below the suggested radiation protection guides and dose limits.

Acknowledgement

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Data

SECTION I. MILK AND FOOD

Milk Surveillance, October 1968

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long term concentration trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN), sponsored by the Bureau of Radiological Health and the Bureau of Community Environmental Management, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments have also initiated local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides occurring or formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium–89, strontium–90, iodine–131, cesium–137, and barium–140. A sixth radionuclide, potassium–40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium–40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

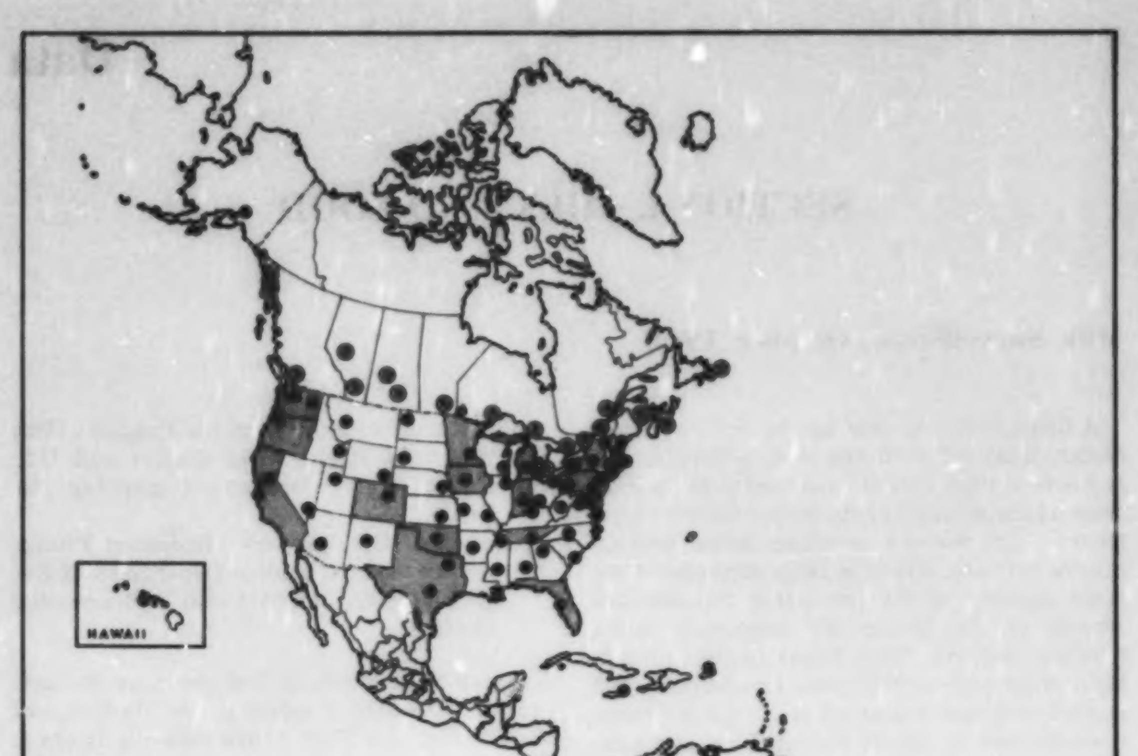
HAWAII
LEGEND:
● Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
○ Pan American Health Organization Sampling Stations
▨ States Presently Reported
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere reported in *Radiological Health Data and Reports*

metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. As a result of a study made of the PMN results for calcium content in milk for the period, May 1963–March 1966, an average value for the PMN and its two standard deviation, 1.16 ± 0.08 g/liter, was developed as an appropriate calcium content in milk for use in general radiological health calculations or discussions (*3*). As a result of a parallel study, an average value for the PMN, 1.51 ± 0.21 g/liter, for potassium content in milk was developed (*3*).

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined in the literature (*4*).

The most recent study was conducted in the spring of 1967, with 40 laboratories participating in an experiment on milk samples containing known concentrations of strontium-90, iodine-131, and cesium-137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 of these laboratories participated in the experiment.

In the majority of cases, the results for the laboratories fell within the 3-standard deviation limits considered appropriate for the various analyses. Several results were outside the 3 standard deviation limits and the most deviant of these represented biases from the expected values of 20 to 30 percent (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error because of disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy on whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis not only varies among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over the time periods involved and sampling frequency is not critical. For the case of the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first

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measurement of recognition of a new influx of the radionuclide.

Also reflected in the data presentation is whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision 2-standard deviations
Strontium-89	1-5 pCi/liter for levels <50 pCi/liter; 5-10% for levels ≥ 50 pCi/liter
Strontium-90	1-2 pCi/liter for levels <20 pCi/liter; 4-10% for levels ≥ 20 pCi/liter
Iodine-131	4-10 pCi/liter for levels <100 pCi/liter; 6-10% for levels ≥ 100 pCi/liter
Cesium-137	4-10 pCi/liter for levels <100 pCi/liter; 4-10% for levels ≥ 100 pCi/liter
Barium-140	5-10 pCi/liter at levels <100 pCi/liter; 6-10% for levels ≥ 100 pCi/liter

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance for the use of Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8-9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/yr)	RPG (rad/yr)	Guidance for suitable samples of exposed population group[a]			
				Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)[b]	Range II (pCi/day)[b]	Range III (pCi/day)[b]
Strontium-89	Bone	1.5	0.5	[c]2,000	0-200	200-2,000	2,000-20,000
	Bone marrow	.5	.17				
Strontium-90	Bone	1.5	.5	[c]200	0-20	20-200	200-2,000
	Bone marrow	.5	.17				
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[d]	Whole body	.5	.17	3,600	0-360	360-3,600	3,600-36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants

[b] Based on an average intake of 1 liter of milk per day.

[c] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third of the respective RPG.

[d] The guides expressed here were not given in the FRC reports, but were calculated using approproptiate FRC recommendations.

from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Protective Action Guides (*10–11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in ex-

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels following an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c]1,110,000
Strontium-90	Bone marrow			[c]51,000
Cesium-137	Whole body			[c]720,000
Iodine-131	Thyroid	30	10	[d]70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered.

Table 3. Concentration of radionuclides in milk for October 1968 and 12-month period, November 1967 through October 1968

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	4	9	0(5)	0	12(5)	13
Alaska:	Palmer[c]	P	7	6	0(2)	0	20(2)	14
Ariz:	Phoenix[c]	P	0	1	0(5)	0	0(5)	2
Ark:	Little Rock[c]	P	20	21	0(4)	0	22(4)	20
Calif:	Sacramento[c]	P	4	3	0(4)	0	6(4)	6
	San Francisco[c]	P	0	1	0(5)	0	0(5)	5
	Del Norte	P	19	19	0	0	31	23
	Fresno	P	0	0	0	0	0	5
	Humboldt	P	0	3	0	0	21	10
	Los Angeles	P	0	0	0	0	16	7
	Mendocino	P	0	3	0	0	0	4
	Sacramento	P	5	2	0	0	0	6
	San Diego	P	0	0	0	0	0	2
	Santa Clara	P	0	0	0	0	0	7
	Shasta	P	4	3	0	0	11	4
	Sonoma	P	0	2	0	0	0	5
Colo:	Denver[c]	P	6	4	0(5)	0	5(5)	6
	West	R	(d)		(e)	(e)	(e)	(e)
	Northeast	R	(d)		(e)(2)	3	(e)(2)	(e)
	East	R	(d)		(e)	(e)	(e)	(e)
	Southeast	R	(d)		NS	(e)	NS	(e)
	South Central	R	(d)		NS	(e)	NS	(e)
Conn:	Hartford[c]	P	4	10	0(4)	0	10(4)	11
	Central	R	7	8	0(4)	0	11(4)	9
Del:	Wilmington[c]	P	6	10	0(5)	0	0(5)	8
D.C.:	Washington[c]	P	8	10	0(4)	0	3(4)	6
Fla:	Tampa[c]	P	8	8	0(5)	0	75(5)	66
	West	R	11	15	0	3	28	25
	North	R	18	16	0	3	40	26
	Northeast	R	10	9	0	2	84	84
	Central	R	6	10	0	8	64	103
	Tampa Bay area	R	6	8	0	0	90	74
	Southeast	R	9	9	0	2	191	100
Ga:	Atlanta	P	12	14	0(5)	0	18(5)	20
Hawaii:	Honolulu[c]	P	6	4	0(4)	1	0(4)	4
Idaho	Idaho Falls[c]	P	4	5	0(4)	0	3(4)	8
Ill:	Chicago[c]	P	9	9	0(4)	0	10(4)	10
Ind:	Indianapolis[c]	P	9	8	0	0	2(4)	7
	Northeast	P	9	9	0	0	15	10
	Southeast	P	10	10	0	0	0	12
	Central	P	9	8	0	0	18	9
	Southwest	P	6	9	0	0	0	13
	Northwest	P	11	9	0	0	12	11
Iowa:	Des Moines[c]	P	9	7	0(5)	0	10(5)	7
	Iowa City	P	5(2)	7	0(2)	0	7(2)	4
	Des Moines	P	5(4)	7	0(4)	0	0(4)	2
	Spencer	P	6	7	0	0	10	4
	Charles City	P	NS	NS	NS	0	NS	NS
Kans:	Wichita[c]	P	8	8	0(4)	0	0(4)	5
Ky:	Louisville[c]	P	12	12	0(4)	0	15(4)	6
La:	New Orleans[c]	P	19	20	0(4)	0	22(4)	23
Maine:	Portland[c]	P	7	12	0(4)	0	25(4)	28
Md:	Baltimore[c]	P	9	10	0(5)	0	6(5)	7
Mass:	Boston[c]	P	7	12	0(5)	0	19(5)	24
Mich:	Detroit[c]	P	6	9	0(5)	0	7(5)	12
	Grand Rapids[c]	P	6	10	0(4)	0	10(4)	15
	Bay City	P	NS	4	NS	(e)	NS	5
	Charlevoix	P	NS	5	NS	(e)	NS	7
	Detroit	P	2(2)	4	(e)	(e)	0	4
	Grand Rapids	P	4	5	(e)	(e)	0	8
	Lansing	P	4(2)	4	(e)	(e)	0	2
	Marquette	P	6	7	(e)	(e)	20	21
	Monroe	P	3	4	(e)	(e)	0	2
Minn:	Minneapolis[c]	P	12	12	0(4)	0	9(4)	12
	Bemidji	P	14	15	0	0	23	21
	Mankato	P	7	6	0	0	0	0
	Rochester	P	11	8	0	0	0	0
	Duluth	P	19	20	0	0	27	29
	Worthington	P	6	6	0	0	0	0
	Minneapolis	P	10	12	0	0	34	12
	Fergus Falls	P	9	9	0	0	13	0
	Little Falls	P	9	9	0	0	12	13
Miss:	Jackson[c]	P	17	17	0(4)	0	16(4)	14
Mo:	Kansas City[c]	P	11	8	0(4)	0	3(4)	5
	St. Louis[c]	P	8	9	0(4)	0	6(4)	8
Mont:	Helena[c]	P	NA	5	0(5)	0	3(5)	8
Nebr:	Omaha[c]	P	5	7	0(4)	0	9(4)	5
Nev:	Las Vegas[c]	P	0	1	0(5)	0	0(5)	4
N.H.:	Manchester[c]	P	11	14	0(5)	0	28(5)	36
N.J.:	Trenton[c]	P	6	10	0(5)	0	5(5)	11
N.Mex:	Albuquerque[c]	P	4	2	0(5)	0	0(5)	2

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for October 1968 and 12-month period, November 1967 through October 1968—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
N.Y.:	Buffalo[c]	P	NA	9	0(4)	0	3(4)	10
	New York City[c]	P	7	12	0(4)	0	14(4)	15
	Syracuse[c]	P	8	9	0(4)	0	3(4)	5
	Albany	P	NA	NA	NA	NA	NA	NA
	Buffalo	P	NA	NA	NA	NA	NA	NA
	Massena	P	NA	NA	NA	NA	NA	NA
	Newburgh	P	NA	NA	NA	NA	NA	NA
	New York City	P	NA	NA	NA	NA	NA	NA
	Syracuse	P	NA	NA	NA	NA	NA	NA
N.C.:	Charlotte[c]	P	18	15	0(5)	1	12(5)	12
N.Dak:	Minot[c]	P	11	11	0(4)	0	11(4)	13
Ohio:	Cincinnati[c]	P	6	9	0(5)	0	0(5)	6
	Cleveland[c]	P	6	10	0(4)	0	0(4)	9
Okla:	Oklahoma City[c]	P	10	10	0(4)	0	8(4)	4
	Oklahoma City	P	(d)		NA	NA	NA	NA
	Enid	P	(d)		NA	NA	NA	NA
	Tulsa	P	(d)		NA	NA	NA	NA
	Lawton	P	(d)		NA	NA	NA	NA
	Ardmore	P	(d)		NA	NA	NA	NA
Ore:	Portland[c]	P	9	7	0(4)	0	10(4)	15
	Baker	P	NS	6	(e)	(e)	(e)	4
	Coos Bay	P	NS	10	(e)	(e)	22	14
	Eugene	P	NS	3	(e)	(e)	(e)	11
	Medford	P	NS	3	(e)	(e)	60	15
	Corvallis	P	NS	NS	(e)	(e)	(e)	3
	Portland composite	P	NS	7	(e)	(e)	(e)(4)	8
	Portland local	P	NS	6	(e)	(e)	11(4)	13
	Redmond	P	NS	4	(e)	(e)	(e)	8
	Tillamook	R	NS	10	(e)	(e)	25	26
	Albany	P	NS	NS	(e)	(e)	(e)	3
Pa:	Philadelphia[c]	P	6	10	0(4)	0	3(4)	9
	Pittsburgh[c]	P	8	12	0(5)	0	4(5)	13
	Dauphin	P	9	8	0	0	0(2)	17
	Erie	P	15	13	0	0	18(2)	22
	Philadelphia	P	7	9	0	0	15(2)	17
	Pittsburgh	P	8	12	0	0	13(4)	15
R.I.:	Providence[c]	P	8	11	0(5)	0	17(5)	18
S.C.:	Charleston[c]	P	16	14	0(5)	0	25(5)	26
S.Dak:	Rapid City[c]	P	8	10	0(4)	0	2(4)	10
Tenn:	Chattanooga[c]	P	12	13	0(4)	0	12(4)	13
	Memphis[c]	P	12	11	0(5)	0	0(5)	4
	Chattanooga	P	11	13	0(4)	1	3(4)	17
	Clinton	P	14	13	0	2	11	20
	Knoxville	P	10	12	0	4	9	15
	Nashville	P	8	8	0	1	0	14
Tex:	Austin[c]	P	0	3	0(3)	0	4(3)	2
	Dallas[c]	P	8	8	0(4)	0	5(4)	5
	Amarillo	R	NA	5	NA	0	NA	0
	Corpus Christi	R	NA	4	NA	0	NA	0
	El Paso	R	NA	1	NA	0	NA	0
	Fort Worth	R	NA	7	NA	0	NA	0
	Harlingen	R	NA	2	NA	0	NA	0
	Houston	R	NA	10	NA	0	NA	10
	Lubbock	R	NA	4	NA	0	NA	0
	Midland	R	NA	4	NA	0	NA	0
	San Antonio	R	NA	3	NA	0	NA	0
	Texarkana	R	NA	11	NA	0	NA	10
	Uvalde	R	NA	3	NA	0	NA	0
	Wichita Falls	R	NA	9	NA	0	NA	0
Utah:	Salt Lake City[c]	P	6	6	0(5)	0	7(5)	12
Vt:	Burlington[c]	P	6	11	0(5)	0	8(5)	9
Va:	Norfolk[c]	P	15	11	0(4)	0	7(4)	9
Wash:	Seattle[c]	P	10	9	0(5)	0	23(5)	21
	Spokane[c]	P	NA	7	0(5)	0	4(5)	10
	Benton County	R	NS	0	NS	0	NS	3
	Deer Park	R	5	3	0	0	(e)	2
	Elma	R	7	4	0	0	(e)	20
	Franklin County	R	0	0	0	0	(e)	(e)
	Moses Lake	R	3	1	0	0	(e)	(e)
	Pierce County	R	4	3	0	0	(e)	8
	Sandpoint, Idaho	R	11	7	0	0	28	22
	Skagit County	R	8	4	0	0	24	15
W.Va:	Charleston[c]	P	9	12	0(5)	0	6(5)	5
Wisc:	Milwaukee[c]	P	5	8	0(3)	0	14(3)	11
Wyo:	Laramie[c]	P	5	4	0(5)	0	12(5)	7
CANADA:								
Alberta:	Calgary	R	7	9	(d)		20	19
	Edmonton	R	8	8	(d)		21	22
British Columbia:								
	Vancouver	R	14	14	(d)		48	31

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for October 1968 and 12-month period, November 1967 through October 1968—Continued

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)					
		Strontium-90		Iodine-131		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA (Continued)							
Manitoba: Winnipeg	R	8	8	(d)		27	25
New Brunswick:							
Fredrickton	R	18	15	(d)		26	25
Newfoundland:							
St. Johns	R	19	21	(d)		43	42
Nova Scotia: Halifax	R	10	12	(d)		21	24
Ontario: Ft. William	R	15	16	(d)		30	29
Ottawa	R	7	9	(d)		20	20
Sault Ste. Marie	R	15	15	(d)		40	32
Toronto	R	4	5	(d)		21	16
Windsor	R	6	5	(d)		11	14
Quebec: Montreal	R	11	10	(d)		18	21
Quebec	R	12	13	(d)		28	28
Saskatchewan:							
Regina	R	8	8	(d)		20	16
Saskatoon	R	11	9	(d)		20	18
CENTRAL AND SOUTH AMERICA:							
Colombia: Bogota	P	0	1	0	0	0	2
Chile: Santiago	P	0	0	0	0	0	0
Ecuador: Guayaquil	P	0	0	0	0	0	0
Jamaica: Kingston	P	4	5	0	0	80	120
Venezuela: Caracas	P	NS		NS		NS	
Canal Zone: Cristobal[c]	P	4	2	0(4)	1	20(4)	10
Puerto Rico: San Juan[c]	P	5	5	0(4)	0	11(4)	10

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado, 25 pCi/liter;
Michigan, 14 pCi/liter;
Oregon, 15 pCi/liter.

Cesium-137: Colorado, 25 pCi/liter;
New York, 20 pCi/liter;
Oregon, 15 pCi/liter;
Washington, 15 pCi/liter.

Strontium-90: New York, 3 pCi/liter

NA, no analysis.
NS, no sample collected.

posure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable, a more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in a retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages that are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

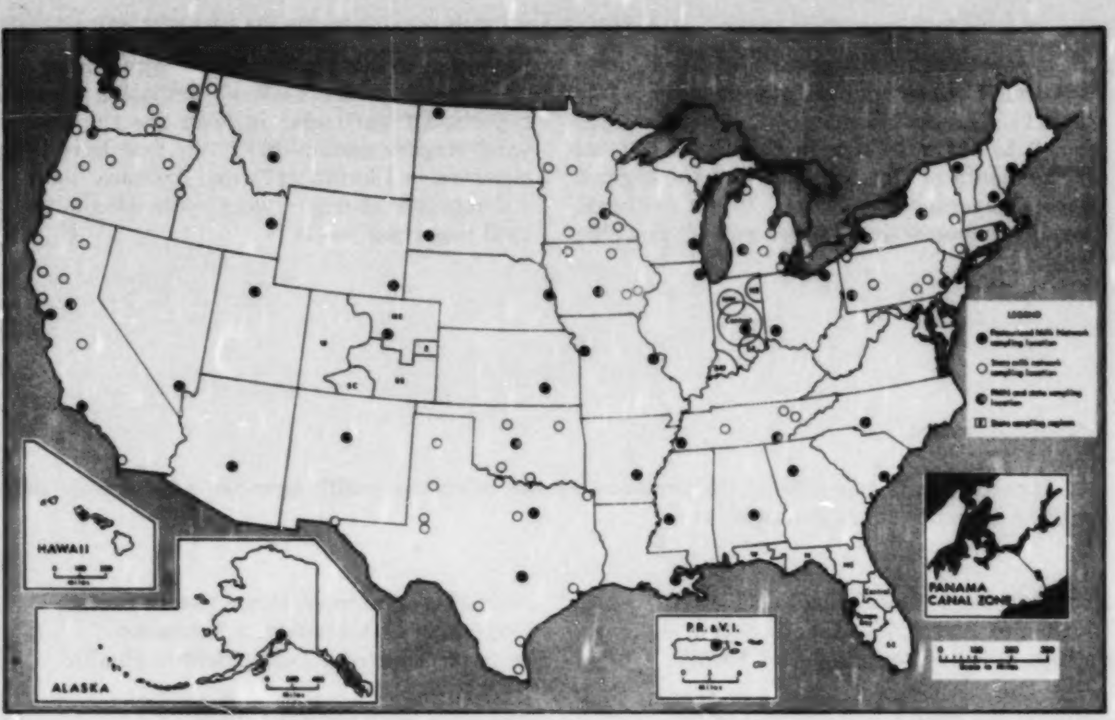

Figure 2. State and PMN milk sampling locations in the United States

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium–90, iodine–131, and cesium–137 for October 1968 and the 12-month period, November 1967–October 1968. Except where noted the monthly average represents a single sample for the sampling station. Strontium–89 and barium–140 data have been omitted from table 3 since levels at the great majority of the stations for October 1968 were below the respective practical reporting levels with the exception of stations given in table 4.

Table 4. Monthly average of strontium–89 and barium–140 in milk, October 1968

Sampling location	Radionuclide concentration (pCi/liter)	
	Strontium–89	Barium–140
Nebraska, Omaha (PMN)	7	
Canal Zone, Cristobal (PMN)	8	
Colombia: Bogota (PAHO)	15	
Chile: Santiago (PAHO)	10	
Ecuador: Guayaquil (PAHO)	10	
Iowa: Des Moines (PMN)		2(5)
Oregon: Portland (PMN)		3(4)
Rhode Island: Providence (PMN)		3(5)

Iodine–131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting levels for iodine–131 are numerically equal to the upper value of Range 1 (10 pCi/liter) of the FRC radiation protection guide.

Strontium–90 monthly averages ranged from 0 to 20 pCi/liter in the United States for the month of October 1968 and the highest 12-month average was 21 pCi/liter (Little Rock, Ark.), representing 9.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137 monthly averages ranged from 0 to 191 pCi/liter in the United States for the month of October 1968 and the highest 12-month average was 109 pCi/liter (Southeast Florida), representing 3.0 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 monthly averages were below all the practical reporting levels.

Acknowledgement

Appreciation is expressed to the personnel of the following health agencies who provide data for their milk surveillance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiological Health Section
Division of Air, Occupational and Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation and Occupational Health Section
Division of Environmental Sanitation
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are:

Program	Period reported	Last presented
California Diet Study	July–October 1967	May 1968
Institutional Diet	April–June 1968	January 1969
Tri-City Diet, HASL	April–December 1967	June 1968

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Last presented
California	July–December 1967	November 1968
Colorado River Basin	1967	December 1968
Florida	1965–1966	July 1968
Minnesota	July–December 1967	October 1968
New York	June–December 1967	October 1968
Radiostrontium in Tap Water, HASL	July–December 1967	June 1968
Washington	July 1966–June 1967	August 1968

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90, respectively.

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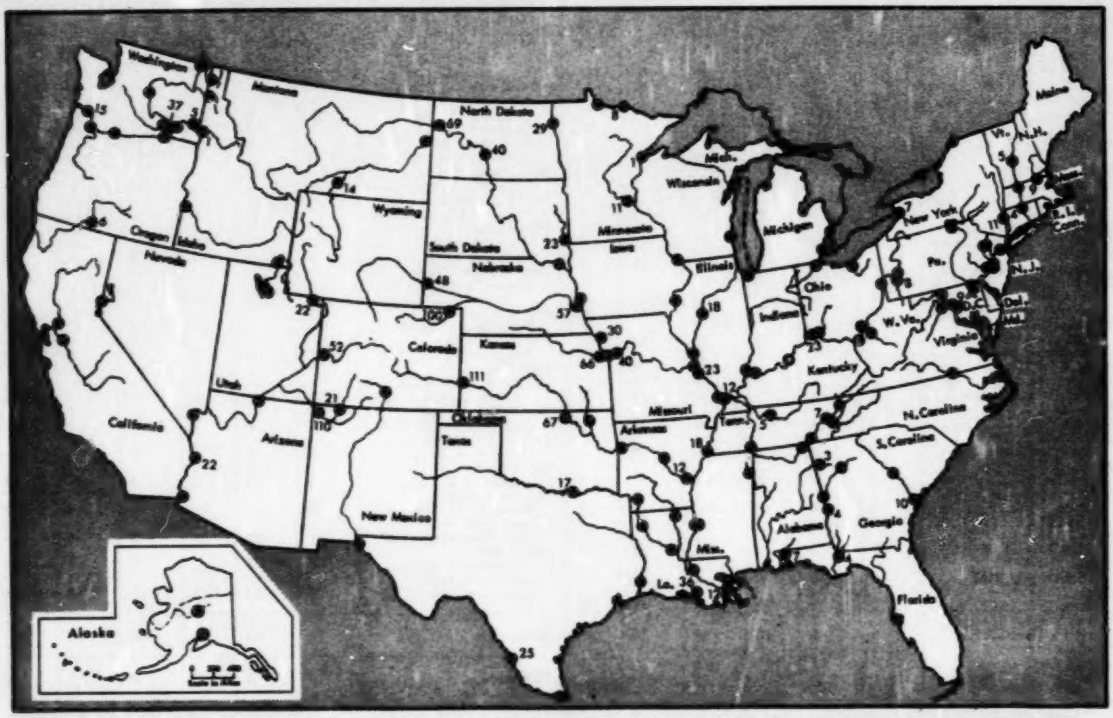
Gross Radioactivity in Surface Waters of the United States, August 1968

Division of Pollution Surveillance
Federal Water Pollution Control Administration, Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System currently operated by the Federal Water Pollution Control Administration. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the November 1968 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A dis-


Washington
Montana
North Dakota
Oregon
Idaho
Wyoming
South Dakota
Nebraska
Nevada
Utah
Colorado
Kansas
California
Arizona
New Mexico
Oklahoma
Texas
Minnesota
Iowa
Wisconsin
Mich.
Michigan
Illinois
Indiana
Ohio
Kentucky
Missouri
Arkansas
Tenn.
Miss.
La.
Alabama
Georgia
Florida
S. Carolina
N. Carolina
Virginia
W. Va.
Pa.
New York
N.J.
Del.
Md.
D.C.
Vt.
N.H.
Maine
R.I.
Conn.
Alaska
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1
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57
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111
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110
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5
7
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34
17
2
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7
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23
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9
5

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, August 1968

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cussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (7). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During August 1968, the following stations showed values in excess of 15 pCi/liter of alpha radioactivity for either suspended or dissolved solids:

Arkansas River; Coolidge, Kans.
Missouri River; Williston, N. Dak.
San Juan River; Shiprock, N. Mex.
South Platte River; Julesburg, Colo.

During this month no station showed beta radioactivity in excess of 150 pCi/liter on suspended or dissolved solids.

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(7) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–15 (January 1968).

Table 1. Radioactivity in raw surface waters, August 1968

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	6	1	7	15	6	21
Apalachicola River:						
Chattahoochee, Fla	1	0	1	0	4	4
Arkansas River:						
Coolidge, Kans	17	19	36	59	52	111
Ponca City, Okla	13	1	14	55	12	67
Pendleton Ferry, Ark	0	0	0	0	12	12
Atchafalaya River:						
Morgan City, La	7	1	8	25	11	36
Big Horn River:						
Hardin, Mont	1	5	6	2	12	14
Big Sioux River:						
Sioux Falls, S. Dak	<1	1	1	2	21	23
Chattahoochee River:						
Columbus, Ga	0	0	0	1	3	4
Clearwater River:						
Lewiston, Idaho	0	0	0	<1	1	1
Clinch River:						
Kingston, Tenn[a]	0	0	0	0	7	7
Colorado River:						
Loma, Colo	11	8	19	39	13	52
Parker Dam, Calif-Ariz	0	4	4	0	22	22
Columbia River:						
Pasco, Wash[a]	0	0	0	13	24	37
Clatskanie, Ore	0	1	1	6	9	15
Connecticut River:						
Wilder, Vt	0	0	0	2	3	5
Enfield Dam, Conn	0	1	1	1	3	4
Coosa River:						
Rome, Ga	0	1	1	0	3	3
Cumberland River:						
Cheatham Lock, Tenn	1	0	1	2	3	5
Escambia River:						
Century, Fla	0	0	0	3	4	7
Great Lakes:						
Duluth, Minn	0	0	0	0	1	1
Buffalo, N.Y	0	1	1	0	7	7
Green River:						
Dutch John, Utah	0	3	3	<1	22	22
Hudson River:						
Poughkeepsie, N.Y	0	0	0	1	10	11
Illinois River:						
Peoria, Ill	1	1	2	6	12	18
Kansas River:						
DeSoto, Kans	9	1	10	53	13	66
Klamath River:						
Keno, Ore	0	<1	<1	<1	6	6
Merrimack River:						
Lowell, Mass	1	0	1	4	5	9
Mississippi River:						
St. Paul, Minn	1	3	4	1	10	11
E. St. Louis, Ill	3	1	4	14	9	23
W. Memphis, Ark	2	1	3	9	9	18
New Orleans, La	1	1	2	3	9	12
Missouri River:						
Williston, N. Dak	16	9	25	56	13	69
Bismarck, N. Dak	0	3	3	2	38	40
St. Joseph, Mo	2	2	4	12	18	30
Missouri City, Mo	4	1	5	21	19	40
Monongahela River:						
Pittsburgh, Pa	0	1	1	1	7	8
North Platte River:						
Henry, Nebr	2	14	16	5	43	48
Ohio River:						
Cincinnati, Ohio	0	0	0	3	20	23
Cairo, Ill	1	0	1	3	9	12
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	<1	<1	0	1	1
Platte River:						
Plattsmouth, Nebr	10	3	13	35	22	57
Potomac River:						
Washington, D.C	1	2	3	3	6	9
Rainy River:						
International Falls, Minn	0	0	0	1	7	8
Red River, North:						
Grand Forks, N. Dak	1	2	3	3	26	29
Red River, South						
Denison, Tex	0	0	0	2	15	17
Rio Grande:						
Laredo, Tex	1	3	4	7	18	25
San Juan River:						
Shiprock, N. Mex	30	2	32	94	16	110
Savannah River:						
Port Wentworth, Ga[a]	<1	<1	<1	2	8	10
Snake River:						
Wawawai, Wash	0	1	1	0	5	5
South Platte River:						
Julesburg, Colo	6	40	46	20	80	100
Maximum	30	40	46	94	80	111
Minimum	0	0	0	0	1	1

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

Radionuclide Analysis of Coast Guard Water Supplies January-December 1967

U.S. Coast Guard[1] and *Bureau of Radiological Health*[2]

Since 1961, water samples have been collected from seven Coast Guard Loran Stations in Alaska and analyzed for radioactivity. These stations are identified as Adak Island, Attu Island, Biorka Island, Cape Sarichef, Port Clarence, Sitkinak Island, and Spruce Cape. Their locations are shown in figure 1.

The principal source of water for these Loran Stations is either lakes or reservoirs, most of which have ice and snow cover for many of the winter months. Water is piped from the reservoirs to storage tanks at the stations. The storage tanks range in capacity from 25,000 to 225,000 gallons. All of the stations chlorinate the water and all but the Attu Island station filter the water prior to use.

One-gallon samples are collected monthly and sent to the Southwestern Radiological Health Laboratory in Las Vegas, Nev. for analysis. The samples are analyzed routinely for gross alpha and gross beta radioactivity. Samples are also analyzed for specific radionuclides if unusual amounts of gross radioactivity are detected.

Gross alpha and gross beta results for the water samples collected during 1967 are shown in table 1. None were found to contain more

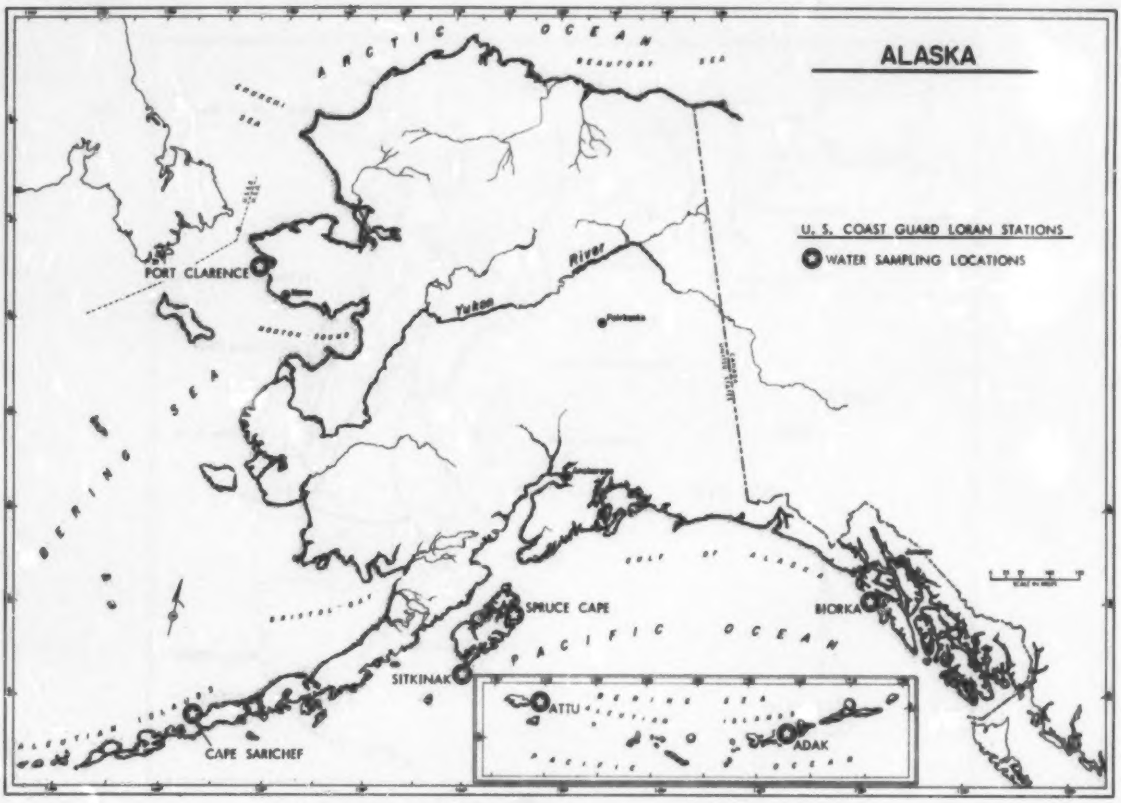
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
ALASKA
U. S. COAST GUARD LORAN STATIONS
WATER SAMPLING LOCATIONS
PORT CLARENCE
NORTON SOUND
Yukon River
Fairbanks
BERING SEA
BRISTOL BAY
GULF OF ALASKA
SPRUCE CAPE
BIORKA
PACIFIC OCEAN
SITKINAK
ATTU
ADAK
CAPE SARICHEF
ALEUTIAN ISLANDS

Figure 1. Coast Guard Loran station water sampling locations

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[1] U.S. Department of Transportation.
[2] U.S. Public Health Service.

Table 1. Radioactivity in water samples from U.S. Coast Guard Loran Stations, January-December 1967

Month (1967)	Adak Island		Attu Island		Biorka Island		Cape Sarichef		Port Clarence		Sitkinak Island		Spruce Cape	
	α	β	α	β	α	β	α	β	α	β	α	β	α	β
January	[a] 0	[a] 0	0	3	0	13	0	8	0	8	NS	NS	0	0
February	0	10	0	5	0	10	0	0	0	10	NS	NS	0	0
March	0	[b] 20	0	0	0	6	0	6	0	0	0	8	0	0
April	0	3	0	4	0	9	0	3	0	18	NS	NS	0	4
May	0	0	0	6	0	9	0	5	0	15	NS	NS	0	7
June	0	3	0	4	0	9	NA	NA	0	9	NS	NS	0	18
July	0	4	NA	NA	0	9	0	4	0	6	0	3	0	3
August	0	3	0	0	0	8	0	0	0	4	NS	NS	0	3
September	0	4	NS	NS	0	6	0	0	0	7	NS	NS	0	0
October	0	4	0	0	NS	NS	0	3	0	8	0	7	0	0
November	0	8	0	0	0	5	0	0	NS	NS	NS	NS	0	3
December	3	8	0	7	0	3	0	7	0	14	NS	NS	0	0

[a] Values equal to or less than 2 pCi/liter gross alpha or gross beta radioactivity are reported as zero.
[b] Strontium-90 concentration was 6 pCi/liter.
NA, no analysis.
NS, no sample received.

than 3 pCi/liter gross alpha. Only six samples contained more than 10 pCi/liter gross beta; Adak Island, 20 pCi/liter (March); Biorka Island, 13 pCi/liter (January); Port Clarence, 18 pCi/liter (April), 15 pCi/liter (May), 14 pCi/liter (December); and Spruce Cape, 18 pCi/liter (June). Of these, only Adak Island had a measureable quantity of strontium-90 (6 pCi/liter).

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
January-Lecember 1965	November 1966
January-December 1966	November 1967

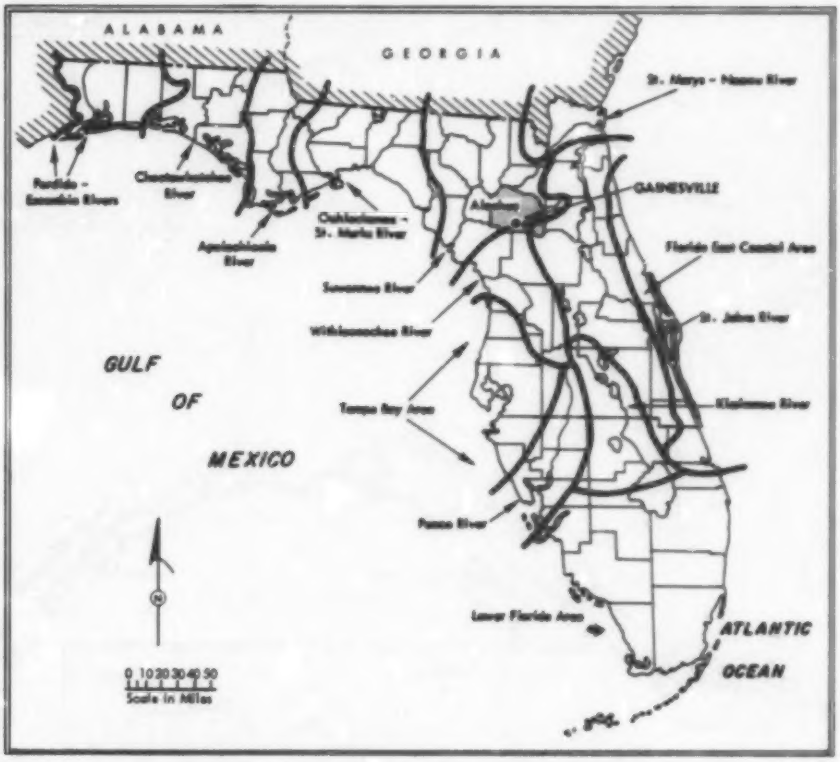
ALABAMA
GEORGIA
St. Marys - Nassau River
Perdido - Escambia Rivers
Choctawhatchee River
GAINESVILLE
Alachua
Apalachicola River
Ochlockonee - St. Marks River
Florida East Coastal Area
Suwannee River
St. Johns River
Withlacoochee River
GULF
OF
MEXICO
Tampa Bay Area
Kissimmee River
Peace River
N
Lower Florida Area
ATLANTIC
OCEAN
0 10 20 30 40 50
Scale in Miles

Figure 1. Hydrological surface subbasins in Florida

Radioactivity in Florida Waters, 1967[1]

Division of Radiological Health
Florida State Board of Health

The Florida State Board of Health samples raw surface, ground, and treated water in 13 hydrological subbasins as shown in figure 1. Samples collected on a variable frequency and analyzed for gross alpha and beta radioactivity during 1967 are presented in table 1. Gross alpha and beta radioactivity concentrations of less than 7 pCi/liter and less than 10 pCi/liter, respectively, are not reported.

In addition to sampling being done by the Florida State Board of Health, the Bioenvironmental Engineering Research Laboratory, University of Florida, samples surface, ground and municipal water in Alachua County for gross beta radioactivity. Samples are taken monthly from each sampling point with the exception of the City of Gainesville where raw water is sampled daily. These data for 1967 are summarized in table 2. Gross beta radioactivity above the minimum reported concentration was detected in 26 water samples taken in Alachua County. The 26 samples averaged 14 pCi/liter of gross beta radioactivity.

During 1967, 28 samples out of a total of 396 collected from 199 sampling sites showed gross beta radioactivity greater than the minimum reported concentration. Twenty-four surface, ground, and municipal water samples averaged 28 pCi/liter and four seawater samples averaged 215 pCi/liter of gross beta radioactivity.

Table 1. Gross alpha and beta radioactivity in Florida waters, 1967

Location subbasin	Number of samples	Alpha (pCi/liter)	Beta (pCi/liter)
Perdido-Escambia Rivers	10	<7	<10
Choctawatchee River	16	<7	<10
Apalachicola River	14	<7	<10
Ochlockonee-St. Marks Rivers	12	<7	<10
Suwannee River	4	<7	<10
St. Mary's-Nassau Rivers	5	<7	<10
	[a] 1	<7	165.0
St. Johns River	117	<7	<10
	[a] 5	<7	10.0
	[a] 3	<7	11.0
	[a] 2	<7	12.0
	[a] 1	<7	13.0
	[a] 1	<7	16.0
	[a] 1	<7	20.0
	[b] 1	<7	31.0
	[a] 1	<7	45.0
Withlacoochee River	20	<7	<10
Tampa Bay area	31	<7	<10
Peace River	18	<7	<10
	[b] 1	0.0	<10
Kissimmee River	8	<7	<10
	[a] 2	<7	22.0
Florida East Coastal area	39	<7	<10
	[a] 1	<7	15.0
Lower Florida area	73	<7	<10
	[a] 1	<7	10.0
	[c] 1	<7	10.0
	[c] 1	<7	11.0
	[c] 1	<7	12.0
	[c] 1	<7	44.0
	[d] 1	15.0	130.0
	[d] 1	<7	194.0
	[d] 1	<7	223.0
	[d] 1	<7	314.0

[a] Raw surface water.
[b] Treated water.
[c] Raw water supply.
[d] Sea water from Biscayne Bay.

The average gross beta radioactivity in water samples is well below the limitations imposed by the standard for gross beta radioactivity in drinking water (1,000 pCi/liter) (*1*). Only one treated and one sea water sample showed gross alpha radioactivity greater than the minimum reported concentration.

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Public Health Service Drinking Water Standards, Revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Table 2. Gross beta radioactivity in Florida water, 1967

Location	Radioactivity concentration (pCi/liter)												
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Average
Alachua County: (19 sampling locations)													
Maximum	12.2	16.9	5.1	9.7	17.7	27.3	15.6	16.0	10.1	13.5	15.1	9.2	14.0
Average	4.2	5.1	1.9	2.1	5.2	7.1	3.8	5.1	3.2	5.7	6.1	3.3	4.4
City of Gainesville:													
Maximum	6.7	28.7	9.3	20.2	11.4	13.9	11.8	5.1	9.7	12.6	11.4	11.4	12.6
Average	2.8	5.3	1.8	3.8	4.2	4.0	2.6	1.3	2.4	3.4	6.0	4.7	3.5

[a] All beta radioactivity minimum values were of background level.

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[1] Data taken from "Report of Florida Radiological Surveillance Programs, 1967" Bureau of Preventable Diseases, Division of Radiological Health, Jacksonville, Fla.

Radioactivity in Minnesota Municipal Water Supplies[1] January-June 1968

Division of Environmental Sanitation, Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). "Grab" samples of raw and treated water are collected weekly at Hallock, East Grand Forks, Eveleth, Fairmont, and St. Paul, and monthly at Crookston, International Falls, and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

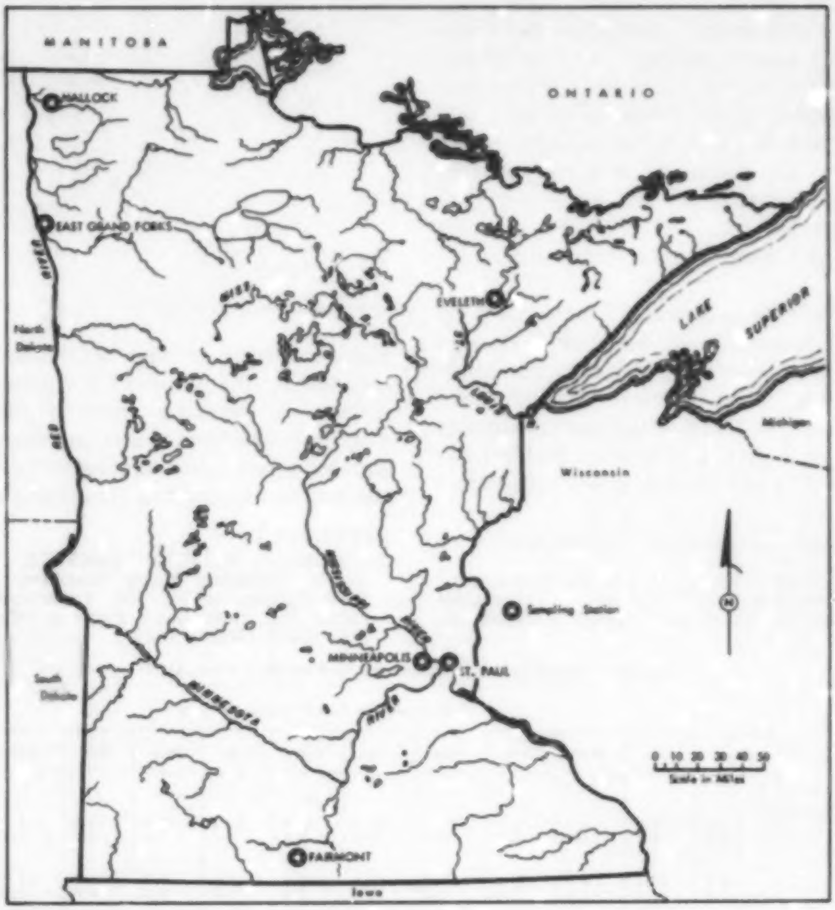
MANITOBA
ONTARIO
HALLOCK
EAST GRAND FORKS
RED RIVER
North Dakota
EVELETH
LAKE SUPERIOR
ST. LOUIS RIVER
Michigan
Wisconsin
MISSISSIPPI RIVER
Sampling Station
N
MINNEAPOLIS
ST. PAUL
South Dakota
MINNESOTA RIVER
0 10 20 30 40 50
Scale in Miles
FAIRMONT
Iowa

Figure 1. Minnesota surface water sampling locations

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[1] Data and information from "Survey of Environmental Radioactivity, January-June 1968," Publication No. C00-651-64. State of Minnesota Department of Health, University Campus, Minneapolis, Minnesota 55440.

The samples are forwarded to the Division's laboratory, where they are analyzed for gross alpha and beta radioactivity. A 250-ml sample of water is transferred to a 2-inch planchet and evaporated at 75° C. The solid residue (suspended-plus-dissolved solids) is fixed by adding lucite in acetone. The sample is then counted for alpha or beta radioactivity in an internal-proportional counter. Counter standardization is accomplished by adding known amounts of thallium-204 standard to solutions containing the normal range of solids.

Table 1 shows a summary of the monthly average gross beta radioactivity in Minnesota municipal water supplies from January-June 1968. Table 2 shows the gross alpha radioactivity in the same samples for the same period of time. Alpha radioactivity reported as <1 pCi/liter was considered as 0.5 pCi/liter for averaging purposes.

The data obtained on gross beta radioactivity in Minnesota surface waters show a variation of concentrations with no readily apparent trends. Variations in precipitation and flow rates of streams could contribute to this fluctuation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 5 to 30 pCi/liter, which is well below the Public Health Service Drinking Water Standards (*1*).

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July-December 1967	October 1968

Table 1. Total beta radioactivity in Minnesota raw and treated water supplies, January-June 1968

Town and water source	Type of water	Average concentration (pCi/liter)					
		Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	22	20	14	16	15	17
	Treated	21	18	18	13	16	17
East Grand Forks, Red Lake River	Raw	15(5)*	17(4)	18(4)	13(5)	13(4)	15(4)
	Treated	8(5)	8(4)	10(4)	9(5)	8(4)	19(4)
Eveleth, St. Mary's Lake	Raw	15(5)	13(3)	12(5)	12(4)	13(5)	17(4)
	Treated	12(5)	11(3)	12(5)	14(4)	16(5)	13(4)
Fairmont, Budd Lake	Raw	12(6)	14(5)	13(3)	23(5)	14(5)	14(3)
	Treated	7(6)	5(5)	7(3)	7(5)	10(5)	7(3)
Hallock, Two Rivers South Fork	Raw	20(5)	21(4)	29(4)	15(4)	15(5)	19(4)
	Treated	10(5)	9(4)	12(4)	7(4)	8(5)	10(4)
International Falls, Rainy River	Raw	9	6	6	9	12	5
	Treated	7	8	7	7	8	10
Minneapolis tap water	Raw						
	Treated	5(5)	6(4)	7(4)	7(5)	8(5)	7(4)
St. Cloud, Mississippi River	Raw	9	8	8	10	10	15
	Treated	5	6	5	7	8	7
St. Paul, Vadnais Chain of Lakes	Raw	9(5)	9(4)	10(4)	9(5)	11(4)	12(4)
	Treated	7(5)	5(4)	7(4)	7(5)	6(4)	8(4)

* Number in parentheses gives number of samples averaged.

Table 2. Total alpha radioactivity in Minnesota raw and treated water supplies, January-June 1968

Town and water source	Type of water	Average concentration (pCi/liter)					
		Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	1	<1	2	8	2	<1
	Treated	<1	<1	1	<1	<1	2
East Grand Forks, Red Lake River	Raw	1(4)*	<1(4)	1(4)	2(5)	3(4)	4(4)
	Treated	<1(5)	1(4)	<1(4)	<1(5)	<1(4)	1(4)
Eveleth, St. Mary's Lake	Raw	<1(5)	<1(3)	<1(5)	<1(4)	<1(5)	<1(4)
	Treated	<1(5)	<1(3)	<1(5)	<1(4)	<1(5)	<1(4)
Fairmont, Budd Lake	Raw	4(6)	5(5)	5(3)	4(5)	4(5)	3(3)
	Treated	<1(6)	1(5)	<1(3)	<1(5)	<1(5)	1(3)
Hallock, Two Rivers South Fork	Raw	1(5)	1(4)	<1(4)	2(4)	3(5)	3(4)
	Treated	1(5)	<1(4)	1(4)	<1(4)	<1(5)	<1(4)
International Falls, Rainy River	Raw	<1	<1	<1	<1	1	<1
	Treated	<1	<1	<1	1	<1	<1
Minneapolis tap water	Raw						
	Treated	<1(5)	<1(4)	<1(4)	<1(4)	<1(4)	<1(4)
St. Cloud, Mississippi River	Raw	<1	<1	<1	2	1	<1
	Treated	<1	<1	<1	<1	<1	<1
St. Paul, Vadnais Chain of Lakes	Raw	<1(5)	1(4)	<1(4)	<1(5)	<1(4)	<1(4)
	Treated	<1(5)	<1(4)	<1(4)	<1(5)	<1(4)	<1(4)

* Number in parentheses gives number of samples averaged.

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
HASL Fallout Network	July–December 1967	September 1968
HASL 80th Meridian Network	Calendar Year 1966	December 1968
Plutonium in Airborne Particulates	January–March 1968	January 1969

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1. Radiation Alert Network October 1968

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed and at 29 hours after collection when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. Compilation of the daily field estimates is reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during October 1968. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

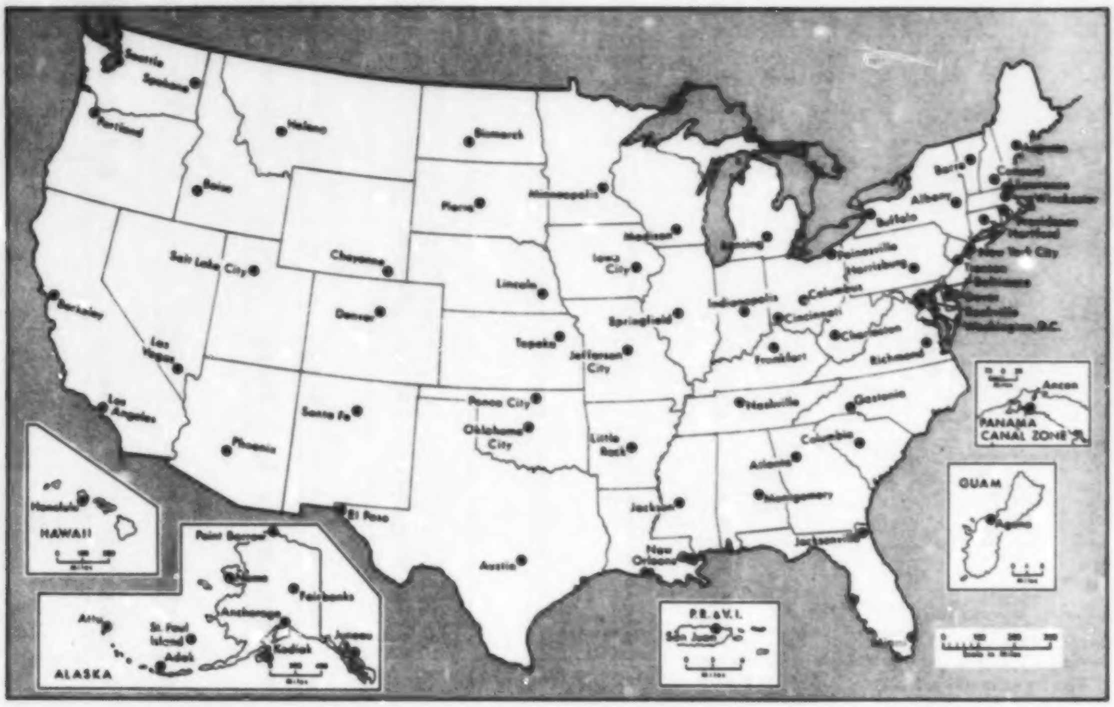
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Salt Lake City
Cheyenne
Berkeley
Lincoln
Denver
Las Vegas
Topeka
Jefferson City
Los Angeles
Ponca City
Santa Fe
Oklahoma City
Phoenix
El Paso
Austin
Little Rock
Honolulu
HAWAII
Point Barrow
Fairbanks
Anchorage
Attu
St. Paul Island
Kodiak
Juneau
Adak
ALASKA
Madison
Iowa City
Lansing
Springfield
Indianapolis
Columbus
Cincinnati
Charleston
Frankfort
Richmond
Painesville
Harrisburg
Buffalo
Albany
Barre
Concord
Winchester
Hartford
New York City
Trenton
Baltimore
Washington, D.C.
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Jackson
New Orleans
Jacksonville
Ancon
PANAMA CANAL ZONE
GUAM
Agana
P.R. & V.I.
San Juan
Scale in Miles

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, October 1968

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation				
							Number of samples	Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average[a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	23	10	0	4	Feb 69	1	40	1	40	37
Alaska:	Adak	31	2	1	2	Feb 69	(c)				
	Anchorage	11	0	0	0	Oct 68	1	8	(d)		
	Attu Island	13	1	0	0	May 68	(c)				
	Fairbanks	(b)				Nov 68	(c)				
	Juneau	22	0	0	0	Dec 68	14	203	14	203	0
	Kodiak	24	1	0	0	Jan 69	(c)				
	Nome	(b)				July 68	(c)				
	Point Barrow	31	4	0	1	June 68	(c)				
	St. Paul Island	31	1	1	1	Aug 68	(c)				
Ariz:	Phoenix	21	15	2	8	Dec 68	(c)				
Ark:	Little Rock	(b)				Oct 68	(c)				
Calif:	Berkeley	23	2	0	1	Jan 69	2	17	2	17	0
	Los Angeles	(b)				July 68	(c)				
C.Z.:	Ancon	19	0	0	0	Jan 69	(c)				
Colo:	Denver	22	10	2	4	Jan 69	2	10	(d)		
Conn:	Hartford	22	1	0	0	Nov 68	3	35	3	35	12
Del:	Dover	21	1	0	0	Sept 68	(c)				
D.C.:	Washington	4	0	0	0	June 68	(c)				
Fla:	Jacksonville	23	1	0	1	Oct 68	9	108	9	108	88
	Miami	16	0	0	0	Nov 68	9	215	9	215	0
Ga:	Atlanta	23	2	0	1	Aug 68	2	57	2	57	30
Guam:	Agana	(b)				Sept 68	(c)				
Hawaii:	Honolulu	30	1	0	1	May 68	1	4	(d)		
Idaho:	Boise	23	8	1	5	May 68	4	23	4	23	10
Ill:	Springfield	19	3	0	1	June 68	3	34	0	0	(e)
Ind:	Indianapolis	23	3	0	2	Aug 68	2	15	2	15	22
Iowa:	Iowa City	22	7	0	1	Jan 69	2	53	2	53	0
Kans:	Topeka	23	3	0	1	Oct 68	6	104	6	104	0
Ky:	Frankfort	16	6	0	1	June 68	5	29	5	29	10
La:	New Orleans	22	3	0	1	June 68	5	66	(d)		
Maine:	Augusta	22	2	0	1	Dec 68	7	87	7	87	0
Md:	Baltimore	23	2	0	1	Nov 68	4	35	4	35	6
	Rockville	13	1	0	0	May 68	(c)				
Mass:	Lawrence	21	1	0	0	Sept 68	3	32	3	32	19
	Winchester	23	3	0	1	Feb 69	5	41	5	41	0
Mich:	Lansing	23	5	0	2	May 68	10	41	10	41	74
Minn:	Minneapolis	23	1	0	0	Sept 68	11	160	10	159	14
Miss:	Jackson	21	4	0	1	Dec 68	1	5	1	5	6
Mo:	Jefferson City	22	2	0	1	Aug 68	6	71	6	71	0
Mont:	Helena	21	9	0	3	Feb 69	2	2	2	2	4
Nebr:	Lincoln	21	5	0	2	Aug 68	4	74	3	62	27
Nev:	Las Vegas	19	6	1	3	Nov 68	(c)				
N.H.:	Concord	22	3	0	1	June 68	(c)				
N.J.:	Trenton	22	4	0	2	Dec 68	2	23	2	23	7
N. Mex:	Santa Fe	20	1	0	1	Feb 69	3	7	3	7	0
N.Y:	Albany	24	3	0	1	Aug 68	7	57	7	57	43
	Buffalo	22	1	0	1	Jan 69	(c)				
	New York City	22	2	0	1	Feb 69	(c)				
N.C:	Gastonia	18	13	1	6	Jan 69	3	13	(d)		
N. Dak:	Bismarck	21	5	1	2	June 68	(c)				
Ohio:	Cincinnati	(b)				Sept 68	(c)				
	Columbus	20	6	1	2	Dec 68	4	60	0	0	(e)
	Painesville	23	1	0	1	Nov 68	10	12	10	12	7
Okla:	Oklahoma City	19	2	0	1	May 68	2	46	2	46	0
	Ponca City	21	4	1	2	Nov 68	4	56	4	56	7
Ore:	Portland	21	1	0	0	Aug 68	12	101	12	101	0
Pa:	Harrisburg	18	2	0	1	Aug 68	(c)				
P.R:	San Juan	(b)				Dec 68	(c)				
R.I:	Providence	22	2	0	1	May 68	4	34	4	34	9
S.C:	Columbia	21	3	0	1	Feb 69	4	127	4	127	26
S. Dak:	Pierre	5	11	5	7	Dec 68	(c)				
Tenn:	Nashville	20	4	0	1	May 68	5	73	5	73	0
Tex:	Austin	22	10	2	4	Sept 68	3	15	(d)		
	El Paso	21	6	1	3	June 68	(c)				
Utah:	Salt Lake City	20	3	0	2	July 68	3	30	3	30	12
Vt:	Barre	16	5	0	1	Oct 68	8	48	8	48	0
Va:	Richmond	19	1	0	0	Oct 68	1	19	1	19	3
Wash:	Seattle	25	0	0	0	Oct 68	11	57	(d)		
	Spokane	11	3	0	1	Sept 68	5	20	5	20	11
W. Va:	Charleston	21	2	0	1	Feb 69	5	76	5	76	61
Wisc:	Madison	20	1	0	1	Oct 68	6	152	5	151	76
Wyo:	Cheyenne	23	7	1	3	Nov 68	4	25	4	25	29
Network summary		1,355	15	0	2		4	65	5	57	17

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] Indicates no report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

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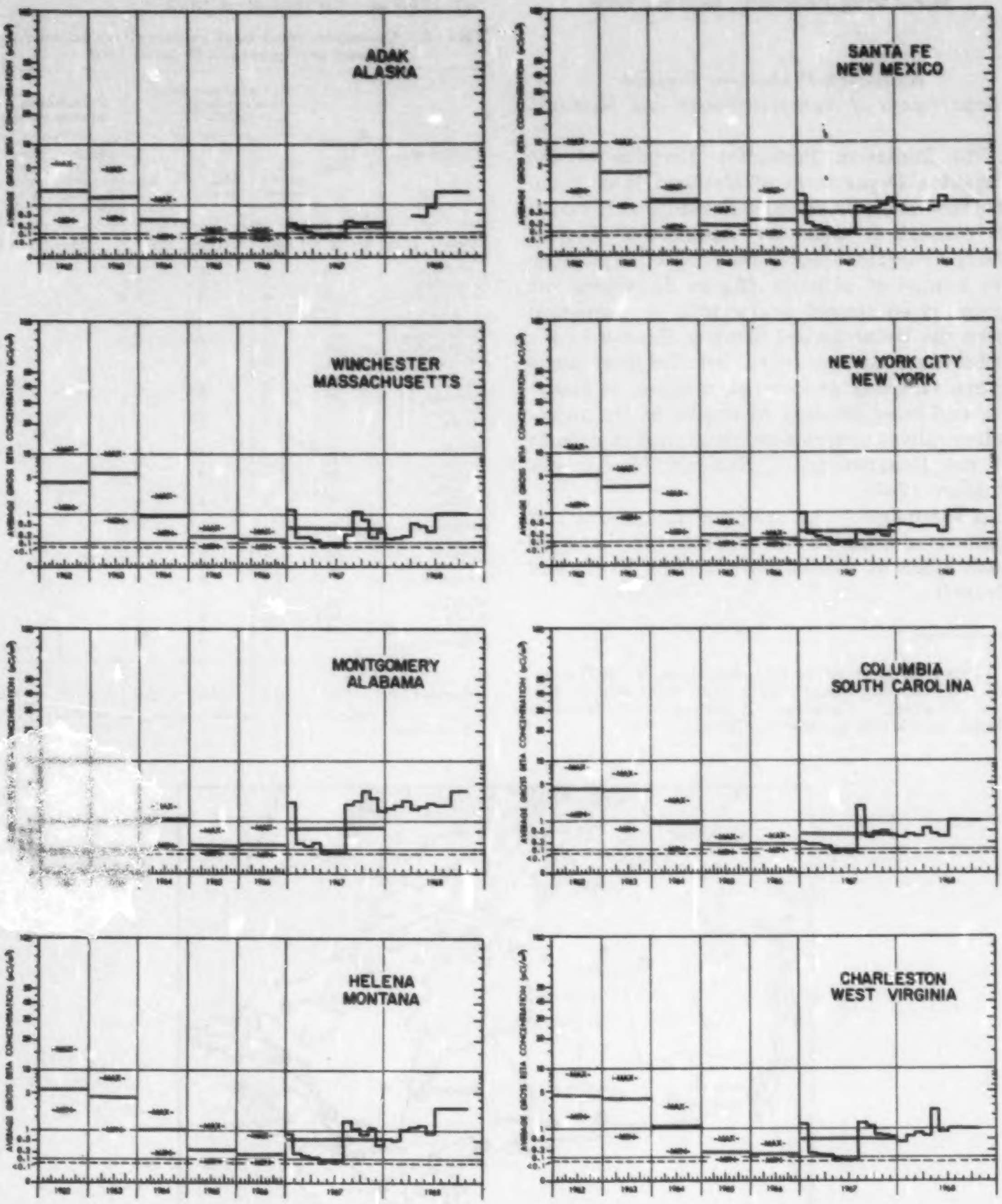

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1962–October 1968

2. Canadian Air and Precipitation Monitoring Program[1], October 1968

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the April 1968 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for October 1968 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, October 1968

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	31	0.1	0.0	0.1	NA	NA
Coral Harbour	29	.1	.0	.0		
Edmonton	31	.1	.0	.0		
Ft. Churchill	30	.1	.0	.0		
Ft. William	31	.1	.0	.0		
Fredericton	31	.1	.0	.0		
Goose Bay	29	.1	.0	.0		
Halifax	31	.2	.0	.1		
Inuvik	31	.0	.0	.0		
Montreal	27	.3	.0	.1		
Moosonee	31	.1	.0	.0		
Ottawa	31	.2	.0	.1		
Quebec	31	.1	.0	.0		
Regina	31	.1	.0	.0		
Resolute	29	.1	.0	.0		
St. John's, Nfld	31	.1	.0	.0		
Saskatoon	31	.1	.0	.0		
Saulte Ste. Marie	31	.2	.0	.1		
Toronto	29	.1	.0	.1		
Vancouver	31	.1	.0	.0		
Whitehorse	31	.1	.0	.1		
Windsor	30	.1	.0	.0		
Winnipeg	24	.1	.0	.0		
Yellowknife	31	.1	.0	.0		
Network summary	723	0.3	0.0	0.0	NA	NA

NA, no analysis.

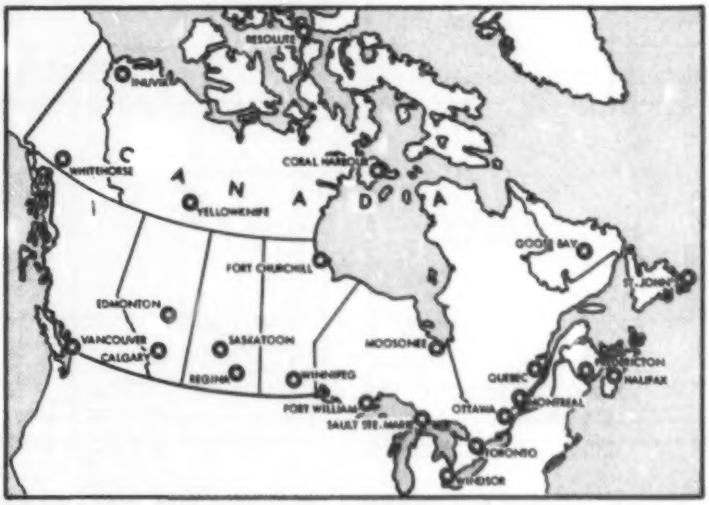
RESOLUTE
INUVIK
WHITEHORSE
C A N A D A
YELLOWKNIFE
CORAL HARBOUR
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
SASKATOON
VANCOUVER
CALGARY
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
MONTREAL
OTTAWA
FORT WILLIAM
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data in the November 1968 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Mexican Air Monitoring Program
June 1968

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4) 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Prevision del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

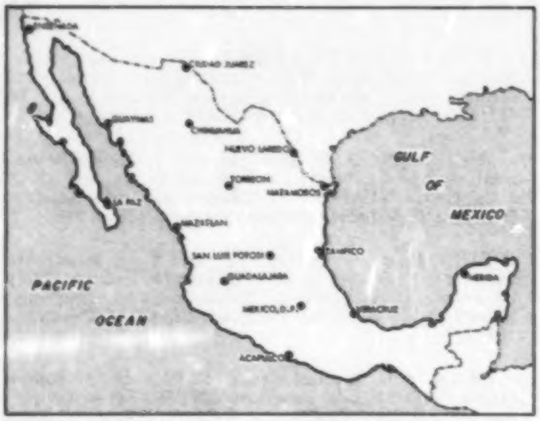

Figure 4. Fallout network sampling stations in Mexico

Sampling

The sampling procedure involves drawing air through a high efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (7).

The maximum, minimum, and average beta radioactivity in surface air during June 1968 are presented in table 3.

Table 3. Mexican gross beta radioactivity of airborne particulates, June 1968

Station	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average
Acapulco	15	0.7	0.1	0.1
Chihuahua	15	1.1	.1	.3
Ciudad Juáres	15	.8	.1	.3
Ensenada	8	1.7	.1	.4
Guadalajara	NS	NS	NS	NS
Guaymas	NS	NS	NS	NS
La Paz	15	.4	.2	.3
Matamoros	NS	NS	NS	NS
Mazatlán	15	.5	.1	.2
Mérida	10	.3	.1	.2
México, D.F	NS	NS	NS	NS
Nuevo Laredo	NS	NS	NS	NS
San Luis Potosí	NS	NS	NS	NS
Tampico	10	.2	.1	.1
Torreón	19	.3	.1	.2
Veracruz	NS	NS	NS	NS

NS, no sample, station temporarily shutdown.

4. Pan American Air Sampling Program October 1968

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling locations are shown in figure 4. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports.* The October 1968 air monitoring results from the participating countries are given in table 4.

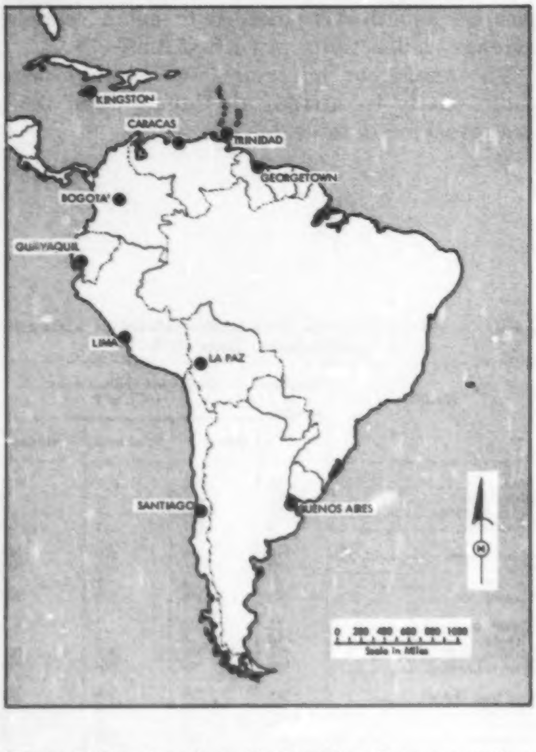

Figure 5. Pan American Air Sampling Program stations

Table 4. Summary of gross beta radioactivity in Pan American surface air, October 1968

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average[a]
Argentina:				
Buenos Aires	NS			
Bolivia:				
La Paz	23	2.29	0.10	0.64
Chile:				
Santiago	30	.60	.06	.25
Colombia:				
Bogata	15	.09	.01	.06
Ecuador:				
Guayaquil	22	.64	.15	.34
Guyana:				
Georgetown	NS			
Jamaica:				
Kingston	23	.13	.03	.07
Lima:				
Peru	9	1.16	.32	.64
Venezuela:				
Caracas	19	1.26	.03	.30
West Indies:				
Trinidad	20	.27	.03	.13
Pan American summary	161	2.29	0.01	0.29

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

NS, no samples received.

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(1) PUBLIC HEALTH SERVICE. Environmental Radiation Surveillance Report. Bureau of Radiological Health, Standards and Intelligence Branch, Rockville, Md. 20852 (Distribution by official request).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare. Ottawa, Canada (May 1960).

(3) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(4) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(5) BEALE, J. and J. GORDON. The operation of the Radiation Protective Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(6) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(7) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la República Mexicana, 1963-1965. Comision Nacional de Energía Nuclear, Dirección General de Sequridad Radiológica (1966).

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Iodine-131 in Bovine Thyroids, April-June 1968

Bureau of Radiological Health
Public Health Service

The Bureau of Radiological Health established a bovine thyroid network in October 1964 (*1*). Specimens are collected by the Livestock Slaughter Inspection Division, U.S. Department of Agriculture, and are analyzed by gamma-ray spectroscopy for iodine–131 content at the Northeastern Radiological Health Laboratory, Winchester, Mass.

The network consists of collection areas (counties shaded in figure 1) located so as to cover, as nearly as possible, areas near major nuclear reactors, spent-fuel reprocessing plants and nuclear test sites. Details of sampling and analyses have been published earlier (*1*).

The results for July through September 1968 appear in table 1 and are listed chronologically within each State. Moderate elevations in radioactivity were found in 11 States during this period. The most active sample analyzed was collected in Garfield County, Colo., on July 30 and contained 44 pCi iodine–131/g thyroid.

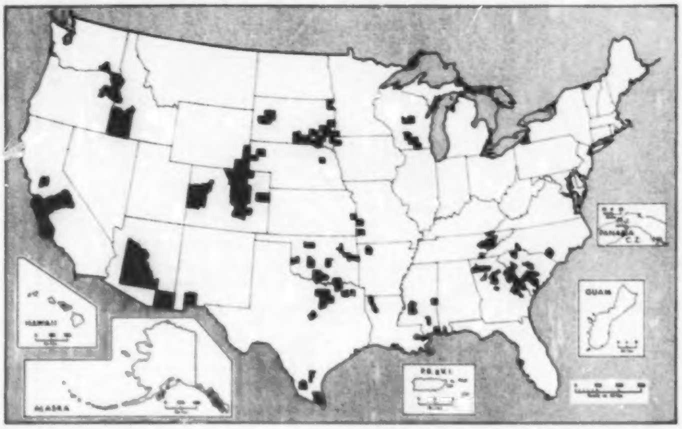

Figure 1. Counties sampled in bovine thyroid network July–September 1968

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October-December 1967	May 1968
January-March 1968	August 1968
April-June 1968	November 1968

REFERENCE

(*1*) BARATTA, E. J., E. R. WILLIAMS, and G. MURRAY. Iodine–131 in bovine thyroids, October-December 1964. Radiol Health Data 6:569–571 (October 1965).

Table 1. Iodine-131 in bovine thyroids, July–September 1968

State	Date of slaughter	County	Number of samples	pCi iodine-131/g thyroid [a]		
				Average or concentration	Minimum	Maximum
Arizona	9/20	Cochise	1	[b] 0		
	[c] 7/12–9/11	Maricopa (14) [d]	18	0		
		Pinal (2)				
		Yavapai (2)				
Arkansas	7/25	Madison	1	0		
California	7/16–9/12	Fresno (1) [d]	26	0		
		Madera (2)				
		Monterey (10)				
		San Benito (10)				
		San L. Obispo (1)				
		San Joaquin (1)				
		Santa Barbara (1)				
Colorado	[c] 7/31–9/30	Adams	7	[b] 0		
	7/17	Arapahoe	1	3		
	[c] 8/15–9/24	Boulder	3	[b] 0		
	7/31	Crowley	1	11		
	[c] 7/16–9/6	Delta	27	[b] 0		
	9/5	Douglas	2	0		
	[c] 7/31–9/25	El Paso	6	2	0	8
	[c] 8/2–9/30	Elbert	2	5	0	10
	[c] 7/30–9/17	Garfield	46	8	0	44
	[c] 7/16–9/27	Jefferson (2) [d]	13	[b] 0		
		Kit Carson (1)				
		Larimer (10)				
	[c] 7/8–9/24	Mesa	35	4	0	22
	[c] 7/23–9/26	Montrose (7) [d]	20	[b] 0		
		Pueblo (2)				
		Teller (1)				
		Weld (10)				
Georgia	[c] 7/2–9/12	Bartow (3) [d]	12	[b] 0		
		Bibb (7)				
		Burke (2)				
	[c] 8/8–9/26	Butts	3	4	0	7
	[c] 7/2–9/12	Candler (7) [d]	32	[b] 0		
		Cherokee (3)		[b] 0		
		Clarke (12)				
		Columbia (2)				
		Emanuel (5)				
		Evans (3)				
	7/31	Floyd	2	3	0	6
	[c] 9/4–9/26	Forsyth	8	2	0	11
	9/25	Fulton	2	14	14	14
	[c] 7/2–9/12	Jasper (2)	22	[b] 0		
		McDuffie (9)				
		Newton (2)				
		Richmond (1)				
		Screven (6)				
		Stephens (2)				
	[c] 7/24–9/26	Walton	6	4	0	10
	[c] 7/2–8/14	Warren (4) [d]	10	[b] 0		
		Wilkes (6)				
Idaho	[c] 7/23–9/28	Ada (11) [d]	32	[b] 0		
		Canyon (9)				
		Elmore (6)				
		Owyhee (3)				
		Washington (3)				
Iowa	9/9	Sioux	8	[b] 0		
Kansas	8/9	Linn	1	0		
Louisiana	[c] 7/31–9/30	Bossier	3	5	0	16
	7/22	Red River	1	0		
Minnesota	7/16	Rock	1	6		
Mississippi	[c] 7/16–7/22		8	0		
	[c] 7/11–8/20	Copiah (2) [d]	22	0		
		Forrest (3)				
		Hinds (6)				
		Jackson (4)				
		Lauderdale (7)				
Missouri	[c] 7/17–8/14	Jasrer (2) [d]	3	0		
		Vernon (1)				
Nebraska	9/30	Box Butte	1	14		
	[c] 7/1–9/24	Madison (2) [d]	4	0		
		Scotts Bluff (2)				
New Mexico	9/27	Luna	2	15	13	16
New York	[c] 7/15–8/24	Chautauqua	60	[b] 0		

See footnotes at end of table.

Table 1. Iodine-131 in bovine thyroids, July–September 1968—Continued

State	Date of slaughter	County	Number of samples	pCi iodine-131/g thyroid [a]		
				Average or concentration	Minimum	Maximum
North Carolina	[c] 8/8–9/17	Cleveland (8) [d]	11	[b] 0		
		Robeson (3)				
Oklahoma	[c] 7/3–7/19		14	0		
	[c] 7/3–7/26	Beckham (2) [d]	5	0		
		Bryan (2)				
		Caddo (1)				
	[c] 7/24–9/28	Carter	6	2	0	11
	[c] 7/3–8/29	Jefferson (3) [d]	23	[b] 0		
		Major (3)				
		Muskogee (3)				
		Pottawatomie (1)				
		Sequoyah (2)				
		Stephens (8)				
		Tulsa (3)				
Oregon	[c] 7/17–9/14	Baker (7) [d]	9	0		
		Wallowa (2)				
South Carolina	7/2–9/17	Bamberg (3) [d]	22	[b] 0		
		Barnwell (3)				
		Colleton (1)				
		Greenwood (3)				
		McCormick (1)				
		Orangeburg (4)				
		Richland (6)				
		Spartanburg (2)				
South Dakota	7/1–9/17	Aurora (3) [d]	15	[b] 0		
		Bon Homme (10)				
		Brookings (2)				
	8/19–9/30	Charles Mix	21	4	0	16
	8/12–9/16	Davison (5) [d]	7	0		
		Gregory (2)				
	7/30–8/7	Hutchinson	13	9	0	27
	7/2–9/25	Lake (1) [c]	33	[b] 0		
		Lincoln (2)				
		McCook (3)				
		Meade (10)				
		Miner (4)				
		Minnehaha (6)				
		Roberts (3)				
		Tripp (4)				
Tennessee	7/2–9/25	Blount (20) [d]	36	[b] 0		
		Claiborne (1)				
		Hamblen (1)				
		Jefferson (3)				
		Knox (11)				
	7/2–9/25	Loudon	8	4	0	12
	9/11	Polk	1	8		
	8/22	Roane	1	10		
	7/24–9/25	Sevier	6	2	0	8
Texas	9/24		3	10	4	14
	[c] 7/19–9/27	Cameron (3) [d]	36	[b] 0		
		Dallas (1)				
		Denton (2)				
		Fannin (1)				
		Hamilton (1)				
		Hopkins (5)				
		Johnson (3)				
		Jim Hogg (10)				
		Jim Wells (3)				
		Tarrant (3)				
		Titus (1)				
		Willacy (2)				
		Wise (1)				
Vermont	[c] 7/3–9/11	Franklin	60	[b] 0		
Washington	[c] 7/30–9/26	Walla Walla	29	0	0	8
Wisconsin	[c] 8/2–9/20	Dane (16) [d]	27	[b] 0		
		Portage (1)				
		Rock (2)				
		Sauk (7)				
		Wood (1)				
Wyoming	[c] 7/23–9/30	Goshen	5	[b] 0		
	[c] 7/16–9/24	Laramie	3	14	4	27

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[a] All results ≤ 2 pCi/g are reported as 0 since at these levels of radioactivity, the 2-standard deviation error is 2 pCi iodine-131/g thyroid.

[b] The results for this period were for the most part nondetectable. Some randomly scattered positive results were obtained but these represented barely detectable amounts of iodine-131 in the bovine thyroid (3 to 5 pCi/g).

[c] Samples were not collected on all dates during this period but the interval includes several sampling dates.

[d] Numbers in parentheses represent the number of samples collected from that county during the interval indicated. These may have been collected over several dates or on only one date.

Strontium-90 in Human Bone, October-December 1967[1]

Bureau of Radiological Health
Public Health Service

To obtain data on the concentration of strontium–90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older age groups have shown their bone strontium–90 content to be low and age-independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained postmortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but is presents some difficulties from the standpoint of infants and children under 5 years of age. Most specimens received to date have been vertebrae and ribs.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the Bureau of Radiological Health at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium–90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium–90 content is then calculated (*3*) from the yttrium–90 activity. For the purpose of maintaining analytical reproductibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples. To further check and maintain analytical accuracy, synthetic "bone ash" samples (calcium phosphate spiked with strontium–90) are analyzed periodically and crosscheck analyses are carried out quarterly with the Health and Safety Laboratory of the AEC, which performs similar analyses.

The analytical results for strontium–90 in individual bones from persons dying during the fourth quarter (October-December 1967) are presented in table 1 in order of increasing age within each geographical region. These

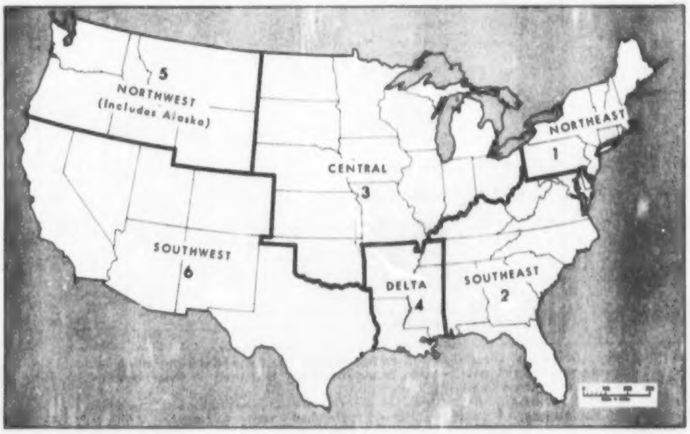

Figure 1. Geographical regions for human bone sampling

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[1] Period during which death or surgical procedure occurred.

Table 1. Human bone network, October–December 1967

Bone region and State		Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration (pCi/kg bone)		Calcium conc. (g/kg bone)	^{90}Sr/ca (pCi/g)
Northeast:	Mass.	V	00	F	89.2	[c]13.0	26.1	3.41
	N.J.	V	00	M	59.5	10.0	41.8	1.42
	Conn.	R	01	M	115.0	17.0	32.8	3.50
	Mass.	V	02	F	131.0	11.0	37.2	3.52
		V	04	F	148.0	12.0	30.6	4.83
	Conn.	V	04	M	49.5	9.7	28.8	1.71
	Mass.	V	04	F	180.0	13.0	35.2	5.11
		V	04	F	150.0	12.0	36.9	4.06
	N.H.	V	04	F	129.0	14.0	35.3	3.65
	Mass.	V	05	M	61.0	8.6	19.3	3.16
	N.Y.	V	05	M	48.3	8.1	56.9	0.84
		V	05	F	80.3	8.5	32.4	2.47
		V	05	F	133.0	14.0	30.3	4.38
	Conn.	V	06	M	59.2	7.8	29.7	1.99
	N.Y.	V	06	M	91.4	9.7	38.4	2.38
		V	06	M	76.7	7.8	30.5	2.51
	Conn.	V, R	08	M	102.0	10.0	40.3	2.53
	Pa.	V	08	F	88.8	10.0	23.9	3.71
	Mass.	V	09	F	158.0	14.0	37.4	4.22
		V	09	F	54.7	9.2	19.5	2.80
		V	10	F	118.0	13.0	41.4	2.85
		V	11	F	60.8	7.8	33.0	1.84
		V	11	F	97.1	7.8	37.6	2.58
		V	12	M	119.0	9.8	31.8	3.74
		V	13	M	67.9	7.0	28.7	2.36
	N.Y.	V	13	M	61.2	7.2	28.2	2.17
	Conn.	V	14	M	112.0	8.5	44.3	2.52
	Pa.	V	14	F	97.7	10.0	39.2	2.49
	Mass.	V	15	M	177.0	12.0	47.4	3.73
	R.I.	V	15	M	82.9	8.1	45.1	1.83
	Pa.	V	15	M	57.8	7.3	31.8	1.81
	N.Y.	V	16	F	94.8	8.8	53.8	1.76
	Vt.	V	16	M	71.2	7.7	40.5	1.75
	Mass.	V	17	M	170.0	9.9	44.8	3.79
		V	17	M	319.0	20.0	64.8	4.92
	Conn.	V	17	M	99.2	10.0	42.6	2.32
	Vt.	V	18	F	225.0	18.0	61.4	3.66
	N.H.	V	19	F	72.0	7.3	43.9	1.64
	Conn.	V	20	M	70.6	9.6	23.4	3.01
	Mass.	V	21	M	120.0	11.0	60.2	1.99
		V	21	F	100.0	8.8	48.0	2.08
		V	21	M	155.0	14.0	59.3	2.61
		V	21	M	121.0	10.0	54.1	2.23
		V	23	M	83.6	8.8	52.1	1.60
		V	24	M	113.0	10.0	60.5	1.86
	N.Y.	V	24	M	122.0	9.1	46.6	2.61
		V	24	F	90.1	8.8	41.5	2.17
		V	25	F	109.0	9.6	51.4	2.12
	Pa.	V	25	M	79.1	9.5	49.6	1.59
Southeast:	N.C.	V	00	M	185.0	12.0	29.0	6.37
	Ga.	V	00	F	143.0	16.0	24.4	5.86
	S.C.	V	01	M	338.0	24.0	39.3	8.60
	Ala.	V	02	F	92.8	15.0	33.3	2.78
	Md.	V	06	M	135.0	15.0	32.6	4.14
		V	08	M	53.7	9.0	33.5	1.60
		V	12	F	78.8	9.5	37.2	2.11
	S.C.	V	12	M	107.0	8.3	35.7	2.99
		V	13	M	113.0	8.2	28.0	4.03
		V	13	F	83.0	6.8	39.0	2.12
	Md.	V	15	M	141.0	10.0	48.4	2.91
		V	15	M	193.0	15.0	52.6	3.66
		V	17	M	148.0	13.0	56.3	2.62
		V	17	M	134.0	13.0	46.9	2.85
		V	17	M	206.0	18.0	60.4	3.41
	Ga.	V	17	M	244.0	16.0	55.9	4.36
	Md.	V	18	F	86.7	7.8	41.3	2.09
		V	19	M	159.0	10.0	47.6	3.34
		V	19	M	177.0	17.0	68.5	2.58
		V	19	F	133.0	10.0	52.1	2.55
		V	19	M	106.0	10.0	48.3	2.19
	S.C.	V	19	M	153.0	14.0	50.3	3.04
		V	19	F	211.0	14.0	48.3	4.36
	Md.	V	20	M	120.0	11.0	57.2	2.09
		V	20	M	92.2	8.0	45.6	2.02
	Ga.	V	20	M	147.0	13.0	54.4	2.70
	Md.	V	20	M	176.0	15.0	45.3	3.88
	N.C.	V	20	M	132.0	13.0	43.8	3.01
	Ga.	V	20	F	136.0	10.0	54.6	2.49
	Md.	V	21	M	133.0	9.5	50.6	2.63
		V	21	F	95.9	8.6	50.9	1.88
		V	22	M	103.0	11.0	51.8	1.98
		V	22	M	107.0	12.0	49.9	2.14
	S.C.	V	22	F	367.0	19.0	55.1	6.66
	Md.	V	23	M	84.2	8.4	46.5	1.81
		V	23	M	86.7	7.8	41.3	2.09
	Ga.	V	23	M	156.0	12.0	43.8	3.56
	Md.	V	24	M	78.8	7.5	43.0	1.83
		V	24	F	97.4	9.9	53.4	1.82
	N.C.	V	24	M	111.0	9.5	43.1	2.57

See footnotes at end of table.

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Table 1. Human bone network, October–December 1967—Continued

Bone region and State		Bone type [a]	Age [b] (years)	Sex	Strontium-90 concentration (pCi/kg bone)		Calcium conc. (g/kg bone)	^{90}Sr/ca (pCi/g)
Central:	Wisc	V	00	M	90.7	17.0	28.5	3.18
		V	00	M	103.0	17.0	32.9	3.13
		V	00	M	56.0	15.0	36.4	1.53
		V	00	M	133.0	19.0	35.1	3.78
		V	01	F	75.7	11.0	27.8	2.72
		V	01	F	69.7	12.0	29.3	2.37
	Ohio	V	01	F	107.0	12.0	26.4	4.05
	Wisc	V	03	M	117.0	9.4	34.9	3.35
	Iowa	V	04	M	87.5	12.0	26.1	3.35
	Wisc	V	06	F	133.0	15.0	33.5	3.97
		V	08	F	72.6	7.4	37.7	1.92
		V	09	M	111.0	11.0	29.3	3.78
		V	13	F	80.2	14.0	37.1	2.16
	Ohio	V	15	F	160.0	17.0	74.1	2.15
	Iowa	V	15	F	75.7	10.0	35.6	2.12
	Ohio	V	17	F	116.0	15.0	63.7	1.82
	Iowa	V	17	M	60.7	7.0	28.4	2.13
	Minn	V	17	M	116.0	12.0	50.0	2.32
	Ohio	V	19	F	120.0	10.0	49.8	2.40
		V	19	M	182.0	19.0	80.6	2.25
	Mich	V	20	M	110.0	8.5	46.7	2.35
	Minn	V	20	M	60.4	6.4	43.5	1.38
	Ohio	V	21	M	65.4	7.6	49.1	1.33
	Minn	V	21	M	84.1	8.3	53.2	1.58
	Ohio	V	21	M	85.9	10.0	72.7	1.18
Delta:	La	V, R	07	F	198.0	12.0	44.4	4.45
		V	14	F	123.0	16.0	26.3	4.67
		V, R	18	F	79.3	7.2	53.0	1.49
		V, R	23	F	410.0	21.0	54.2	7.56
	Tenn	V	24	M	86.6	9.4	47.5	1.82
Northwest:	Ore	V	01	F	101.0	8.1	32.0	3.15
		V	01	M	94.5	8.1	28.2	3.35
		V	01	F	99.9	7.6	31.4	3.18
		V	01	F	165.0	10.0	30.0	5.50
		V	02	F	90.1	6.8	30.7	2.93
		V	07	M	68.2	8.7	33.9	2.01
		V	12	F	56.6	6.5	32.7	1.73
		V	16	M	171.0	12.0	51.4	3.32
		V	17	M	92.4	10.0	48.9	1.91
		V	17	M	116.0	9.5	54.3	2.13
		V	18	M	130.0	10.0	50.0	2.60
		V	18	F	111.0	10.0	51.2	2.16
		V	18	M	101.0	8.6	49.6	2.03
		V	20	M	85.9	7.8	49.5	1.73
		V	21	F	61.4	8.1	51.9	1.18
		V	22	M	52.8	11.0	63.9	0.82
		R	22	M	133.0	19.0	164.0	0.81
		V	23	M	46.3	7.5	53.5	0.86
		V	24	M	76.8	8.4	46.5	1.65
		V	24	F	73.9	9.2	48.6	1.52
		V	24	M	74.2	6.8	47.7	1.55
	Alaska	R	17	F	1,330.0	65.0	159.0	8.36
		R	19	M	381.0	35.0	142.0	2.68
		R	24	M	160.0	23.0	129.0	1.24
Southwest:	Tex	V	01	M	106.0	16.0	31.2	3.39
		V	01	M	89.5	15.0	26.9	3.32
		V	15	F	97.9	14.0	48.8	2.00
		V	19	M	75.7	12.0	53.4	1.41
		T, FI	23	F	80.2	10.0	62.0	1.29

[a] Type of bone: vertebrae, V; rib, R; tibia, T; fibula, FI.
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error.

regions are indicated in figure 1. Reported values are given in picocuries of strontium–90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–5*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April-June 1967	September 1968
July-September 1967	October 1968

REFERENCES

(*1*) RIVERA, J. Stronium–90 in human vertebrae, 1962-1963. Radiol Health Data 5:511–513 (October 1964).

(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY. Stronium–90 content of human bones, 1961-1963. Radiol Health Data 5:231–239 (May 1964).

(*3*) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples, chemical and radiochemical procedures, NERHL 64–1. Northeastern Radiological Health Laboratory, Winchester, Mass. (April 1964).

(*4*) GAFFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Stronium–90 in human bone, 1962-1963. Radiol Health Data 5:620–628 (December 1964).

(*5*) HALLISEY, R. M., and M. A. WALL. Strontium–90 in human bone, 1964-1965. Radiol Health Data Rep 8:415–419 (August 1967).

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Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Knolls Atomic Power Laboratory and the Shippingport Atomic Power Station.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Knolls Atomic Power Laboratory[2]
January–December 1967

General Electric Company
Schenectady, N.Y.

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission, is to support the naval reactor program of the AEC in the development of atomic power for naval propulsion. This includes design, construction, and prototype operation of nuclear power reactors.

The Knolls Atomic Power Laboratory consists of two sites; the Knolls site and the Kesselring site, located as shown in figure 1. The Knolls site occupies approximately 170 acres on which are located administrative buildings; chemistry, physics, metallurgical, engineering, and radioactive materials laboratories; critical assembly buildings; machine shops, decontamination facilities; radioactive waste storage and assembly buildings. The Kesselring site occupies approximately 4,000 acres. Its principal facilities include the Triton (S3G) and Bainbridge (D1G) prototype reactors, equipment service building, fuel service building, and waste treatment facilities. Regular environmental monitoring activities are conducted to assure that laboratory releases of radioactivity to the environment are in compliance with AEC standards.

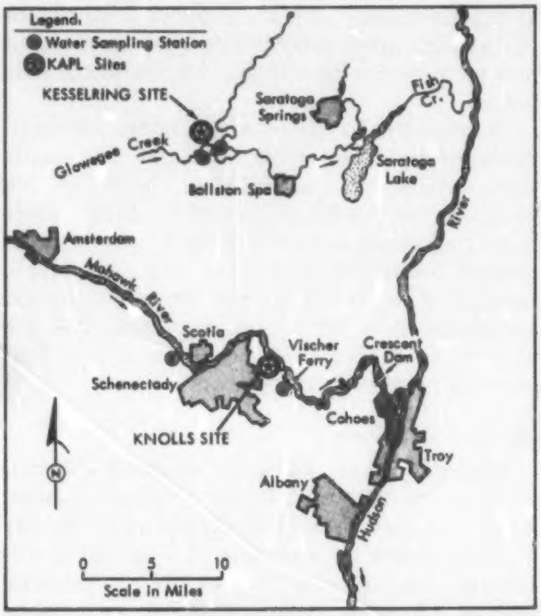

Figure 1. Environmental monitoring locations, KAPL

Air monitoring

Environmental airborne radioactivity is measured at two locations on the Knolls site; at one location at the Kesselring site and at the General Electric Company Research Laboratory approximately 1 mile west of the Knolls site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis.

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[2] Summaried from "Knolls Atomic Power Laboratory, Annual Environmental Monitoring Report, January-December 1967."

The results of the beta-gamma radioactivity analyses of environmental air show average concentrations of 0.06 pCi/m^3 and 0.05 pCi/m^3, at the Knolls and offsite sampling locations, respectively. The results were all less than the most restrictive permissible airborne concentration for beta-emitting radionuclides given in AEC Manual Chapter 0524 (strontium–90, 30 pCi/m^3). Most of the environmental air results were less than 0.05 pCi/m^3, the value considered valid at the 90-percent confidence level with an error of 30 percent. The maximum result (0.17 pCi/m^3 was detected at the Knolls site building K–4 location during the first week of March 1967; this was during a period of low-level fallout from Eastern Hemisphere weapons testing. The results of the beta-gamma long-lived radioactivity analyses of air at the Kesselring site showed an average of 0.07 ± 0.02 pCi/m^3. Environmental air samples at the Kesselring site are counted a minimum of 48 hours after collection to allow short-lived natural radionuclides to decay to nondetectable levels.

In addition to the environmental airborne radioactivity monitoring, surveys are made semiannually of the radiation levels at the perimeter of KAPL, at both sites. A perimeter survey of December 1967 showed normal background radiation levels for the geographic location. The results of this perimeter survey, extrapolated to an annual exposure, indicate average perimeter radiation levels of less than one-tenth of a roentgen per year.

Water monitoring

Mohawk River water is sampled continuously at the General Electric Company powerhouse 8 miles from the Knolls site; at the Vischer Ferry powerhouse 1.7 miles downstream; and at the Cohoes, N.Y. pumping station 13 miles downstream. A continuous sample of Cohoes municiple water, which is derived from river water, is also collected at the Cohoes pumping station. The weekly water samples are composited and analyzed for radioactivity on a monthly basis. Average quarterly beta-gamma concentrations are given in table 1.

Samples of the Glowegee Creek water are analyzed for radioactivity once each quarter year at two locations, one is about 150 feet above the point where the S3G effluent enters the creek and the other is about 1,500 feet below the D1G effluent discharge point.

Table 1. Radioactivity in Mohawk River water near the Knolls site, 1967

1967	Beta and gamma radioactivity (pCi/liter)			
	G.E. powerhouse (upstream)	Vischer Ferry (downstream)	Cohoes River water (downstream)	Municipal water
January–March	5 ±4	8 ±4	4 ±4	7 ±4
April–June	8 ±4	1 ±5	3 ±4	2 ±4
July–September	3 ±4	5 ±4	6 ±5	2 ±5
October–December	7 ±4	6 ±5	7 ±5	3 ±5

The average concentrations of beta and gamma radioactivity detected in Glowegee Creek water upstream and downstream from the S3G and D1G liquid-waste outfalls are shown in table 2.

Table 2. Radioactivity in Glowegee Creek water from the Kesselring site operations, KAPL, January–December 1967

1967	Beta and gamma radioactivity (pCi/liter)	
	Glowegee Creek (upstream)	Glowegee Creek (downstream)
January–March	<4 ±6	<5 ±6
April–June	<2 ±6	<3 ±6
July–September	<6 ±6	<6 ±6
October–December	<1 ±6	<1 ±6

Sediment monitoring

Effective May 1, 1967, the Knolls site Mohawk River monitoring program was extended from an annual to a quarterly collection and analyses of Mohawk River sediment. Samples are collected at fifteen specific locations and all are analyzed for gamma, gross beta, and alpha radioactivity content; in addition, three of the samples are analyzed for strontium–90 content.

The variation in the detectable levels of the analyses of Mohawk River sediment is the result of differences in the size of aliquots analyzed, i.e., 10 grams of sediment for alpha radioactivity analysis, 1 gram for beta radioactivity analysis, 10 grams for strontium–90 separation and the total sample for cesium–137 analysis. The Knolls site radioactive liquid waste disposal program did not adversely influence the radioactivity levels of the Mohawk River sediment. The radioactivity concentra-

Table 3. Radioactivity concentrations in Mohawk River sediment, KAPL, 1967

1967	Number of samples	Total radioactivity (pCi/g)				Strontium-90 [a] (pCi/g)		Cesium-137 (pCi/g)	
		Alpha		Beta					
		Average	Range	Average	Range	Average	Range	Average	Range
May–June	15	<0.74	<0.7-1.3	<22	<22	<2.7	<2.7	<2.9	<1.0-16
July–September	15	<0.85	<0.7-1.2	<22	<22	<2.7	<2.7	<2.1	<1.3- 9.8
October–December	15	<0.81	<0.7-1.8	<22	<22-29	<2.7	<2.7	<5.7	<1.3-52.9

[a] Three samples analyzed for strontium-90.

tions in Mohawk River sediment samples are given in table 3.

Glowegee Creek sediment radioactivity measurements are analyzed on a monthly basis. Sample locations are the same as those listed for Glowegee Creek water sampling. The sediment analysis results are shown in table 4.

Table 4. Radioactivity in Glowegee Creek sediment KAPL, February–December 1967

1967	Location	Number of samples	Gross gamma radioactivity (pCi/g)	
			Average	Range (low/high)
February–March	Upstream	1	4.5	4.5
	Downstream	2	29.2	3.1-55.3
April–June	Upstream	3	4.9	2.7- 8.2
	Downstream	3	3.8	2.3- 6.5
July–September	Upstream	3	1.8	1.6- 2.1
	Downstream	3	3.0	2.3- 3.7
October–December	Upstream	2	1.3	<0.1- 2.5
	Downstream	3	3.1	2.4- 4.1

The high gross gamma radioactivity reading for the one first quarter sample is attributed to fallout which had accumulated on Glowegee Creek ice and was subsequently collected with the sediment sample. Since all other results from upstream and downstream sediment samples are not significantly different, they indicate that Kesselring site operation has not increased the radioactivity of the Glowegee Creek bottom sediment above normal background levels.

Mohawk River fish radioactivity

Specimens of Mohawk River fish are collected annually at the Vischer Ferry Dam at the discharge point of the powerhouse effluent. This location is approximately 9,000 feet downstream of the Knolls site sewage outfall. Samples of the total body are analyzed for gamma radioactivity (cesium-137 equivalent) and samples of the edible tissues are analyzed for strontium-90 content and alpha radioactivity (plutonium-239 equivalent). The specimens, which were all carp, with the exception of one large mouth bass, were collected October 26, 1967.

The results of the radioactivity analyses of Mohawk River fish were all less than the values considered valid at the 90-percent confidence level with a precision of 30-percent. The average results of the eight specimens were: alpha radioactivity, <0.70 pCi/g; strontium-90 content, <0.27 pCi/g; and cesium-137 content, <0.29 pCi/g. The variation in the detectable level of the analyses is the result of differences in the size of aliquots; i.e., 10 grams for alpha radioanalysis, 100 grams for strontium-90 analysis and the total specimen for cesium-137 analysis.

General conclusions

As a result of the environmental monitoring program conducted by the Knolls Atomic Power Laboratory, it is concluded that the operation at the Knolls and Kesselring installations did not adversely affect the radioactivity levels of the local environment. The results of the environmental surveys indicate that the levels of radioactivity detected at all times were within the standards established by the U.S. Atomic Energy Commission in the AEC Manual Chapter 0524, "Radiation Protection Standards."

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January-June 1966	April 1967
July-December 1966	October 1967

2. Shippingport Atomic Power Station[3]
January–December 1967

Duquesne Light Company
Shippingport, Pa.

The Shippingport Atomic Power Station is located on the south bank of the Ohio River in a site consisting of over 400 acres. The site is about 25 miles northwest of Pittsburgh and about 11 miles below the confluence of the Beaver and Ohio Rivers (figure 2). The station is designed to produce electric energy by a conventional central station type turbine-generator unit. The pressurized water reactor consists of a closed system in which water is circulated by pumps over an array of nuclear fuel elements, or core, contained in a reactor vessel, to heat exchangers where steam is formed in a separate isolated system.

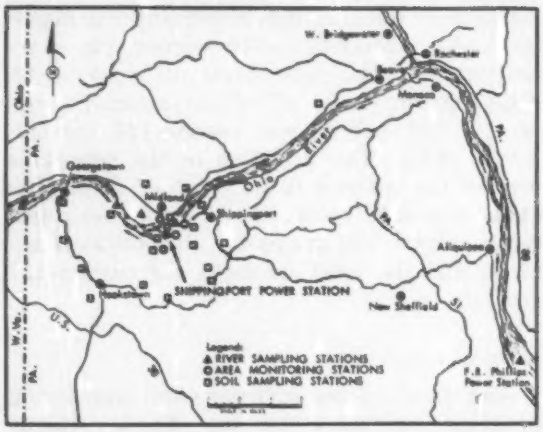

Figure 2. Shippingport power stations sampling locations

Radioactive waste handled under the environmental program includes liquid and gaseous effluents released into the Ohio River and atmosphere, respectively. The levels of radioactivity released were below Shippingport discharge limits. These limits are based upon radiation standards set forth by AEC's division of Operational Safety in directives published in the AEC Manual[4], and a waste discharge permit from the Pennsylvania Sanitary Water Board.

Ohio River water analysis

During 1967, with the exception of the second quarter, weekly composite samples were obtained from two continuous automatic samplers in the station circulating water line upstream and downstream of the radioactive water effluent. During the second quarter of 1967, the two automatic samplers were rendered inoperative; thus, grab samples were collected each day during the radioactive waste discharges and combined at the end of the week into a 2-liter sample. Both suspended and dissolved materials in the composite samples were analyzed for gross alpha and beta radioactivity. Each composite is also analyzed for potassium-40 content. No significant difference was observed among the average alpha, beta, and potassium-40 radioactivity for the influent and effluent samples. The results of these analyses are presented in table 5.

Ohio River sediment analysis

Once during each calendar quarter, sediment samples of the Ohio River were collected upstream and downstream of the circulating water outfall. These samples were quantitated assuming all detected radioactivity to be cobalt-60, which is the major constituent of radioactive contamination at the station. The results of the sediment samples are presented in table 6. These data indicate that there was no increase of radioactivity in the river sediment as a result of the station's discharges.

Gaseous radioactive waste

Gaseous discharges to the atmosphere, identified as xenon-133, are controlled and released at concentrations less than the MPC of 3×10^5 pCi/m^3. During the entire year 1967, less than 1.9 millicuries of xenon-133 were released from the plant site at less than the specified concentration.

Film badge monitoring

Twelve film badges for detecting beta-gamma radioactivity were posted continuously at the

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[3] Summarized from "Environmental Radioactivity at the Shippingport Atomic Power Station for the Calendar Year 1967."

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Table 5. Gross radioactivity in the Ohio River Shippingport Atomic Power Station, January–December 1967,

Type of radioactive material	Average concentration (pCi/liter)							
	Influent samples				Effluent samples			
	First	Second [a]	Third	Fourth	First	Second [a]	Third	Fourth
Alpha:								
Total solids	0.79	1.16	0.63	1.53	0.69	1.26	0.38	0.77
Beta:								
Total solids	16.40	24.17	16.18	13.14	13.44	26.50	19.54	7.99
Potassium-40	3.69	3.3	4.9	3.72	3.77	3.6	4.9	3.75

[a] The average radioactivity for the second quarter of 1967 was computed from grab samples.

Table 6. Total radioactivity in the Ohio River sediment samples, Shippingport, January-December 1967

1967	Number of samples	Gross radioactivity (pCi/g)	
		Upstream	Downstream
January–March	2	8.60	9.35
April–June	2	7.13	6.53
July–September	2	6.04	5.77
October–December	2	6.23	6.40

site perimeter in an attempt to determine the external radiation exposure in the immediate area. In order to accomplish this, a control film badge location was established at a point 10 miles from the station boundary.

During the first and fourth quarters of this report period, the mrem equivalent taken from the normal quarterly film badges was equal to that of the control film. However, during the second and third quarters, differences of readings between the control film and the quarterly site film at several locations ranged up to 25 mrem equivalent. A further check of these differences indicated that they were not attributable to station activities, and that at no time during this report period was there any significant radiation exposure to the general public outside the facility.

Fallout

Precipitation and fallout are collected in a high-walled pot at one location on the site and analyzed monthly for gross alpha and beta radioactivity. A summary of the quarterly averages fallout results for 1967 is presented in table 7.

Table 7. Radioactivity in fallout, Shippingport Atomic Power Station, January–December 1967

1967	Deposition rate (nCi/m²/month)	
	Alpha radioactivity	Beta radioactivity
January–March	0.12	[a]19.1
April–June	.23	3.69
July–September	.12	5.51
October–December	.06	[a]173.5
12-month average	0.15	5.04

[a] The high beta radioactivity reported in the first and fourth quarters of 1967 are attributed to fallout resulting from nuclear weapons testing.

Conclusion

From the data presented above, it may be concluded that during 1967 the radioactive effluent releases from the Shippingport Station site did not cause any significant increase in background radiation levels. In this regard, the station procedures relative to controlling radioactive discharges to the environment are considered to be effective in protecting the health and safety of the general public.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January-June 1966	February 1967
July-December 1966	July 1967

Reported Nuclear Detonations, January 1969

The U.S. Atomic Energy Commission announced three underground nuclear tests for the month of January 1969.

Announcement was made by the U.S. Atomic Energy Commission of two nuclear tests, one of low yield (less than 20 kilotons TNT equivalent) and one of low-intermediate yield (20 to 200 kilotons TNT equivalent) were conducted underground at its Nevada Test Site on January 15, 1969.

A nuclear test of low-intermediate yield (20 to 200 kilotons TNT equivalent) was conducted underground by the Atomic Energy Commission at its Nevada Test Site on January 30, 1969.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

PLUTONIUM-239 IN HUMAN TISSUES AND BONE. *Paul J. Magno and Peter E. Kaufman. Radiological Health Data and Reports, Vol. 10, February 1969*, pp. 47–50.

An average concentration of 7×10^{-11} μCi ^{239}Pu/g was found in human bone samples ranging in age from 2 to 24 years. This concentration results in an average dose equivalent rate of bone of about 3×10^{-4} rem/year. An average concentration of 7×10^{-10} μCi ^{239}Pu/g found in liver samples from older adults results in an average dose equivalent rate of about 7×10^{-4} rem/year. These figures were compared to the Federal Radiation Council's Radiation Protection Guides and the dose limits recommended by the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection. From the data in this report, it was concluded that the concentrations of plutonium-239 in body tissue result in average dose equivalent rates well below the suggested radiation protection guides and dose limits.

KEYWORDS: plutonium-239, bone, liver, spleen, lung, United States, Radiation Protection Guides.

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RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 10, Number 3, March 1969

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

***Radiological Health Data and Reports*, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.**

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Department of Defense
Department of the Interior
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service
Environmental Control Administration ● Bureau of Radiological Health

Reports

Improvement in New York City X-Ray Installations During the First Seven Years of a Radiation Control Program

Hanson Blatz and *Daniel E. Lynch*[1]

The percentage of private medical radiographic units in New York City free from described deficiencies, increased from 8 to 73 percent between 1959 and 1966; for dental radiographic units the increase was from 47 to 89 percent. The percentage of medical radiographic units considered to have adequate x-ray beam filtration increased from 75 to 95 percent in this period; for fluoroscopes the improvement was from 81 to 94 percent; and for dental machines, from 66 to 96 percent. Also during this period, the percentage of machines possessing adequate beam limitation increased as follows: for medical radiographic units, 34 percent to 90 percent; for fluoroscopic units, 40 to 83 percent; and for dental units, 73 to 94 percent.

The inspection of medical and dental x-ray equipment in New York City is under the direction of the Office of Radiation Control, which was established in 1958. Article 175 of the New York City Health Code, entitled "Radiological Hazards," establishes standards for x-ray installations. Except as otherwise specified by the New York City Department of Health, the mandatory recommendations pertaining to medical and dental installations and their equipment and use, of the National Council on Radiation Protection and Measurements, (as shown in the National Bureau of Standards Handbook 76 (*1*)) or equivalent safeguards, are incorporated into the New York City health code and apply to medical and dental installations, their equipment and its use.

Exceptions have been made in enforcement of mandatory recommendations only in a few instances where minor matters of interpretation were involved; in some cases postponement of mandatory recommendations considered to be of secondary importance was permitted for practical reasons. It has been generally interpreted that a dental x-ray machine requires added filtration of 1 mm of aluminum in addition to the 0.5 mm inherent filtration considered to be present in all standard x-ray equipment. In the case of medical x-ray machines, 2 mm of additional aluminum filtration is required. No consideration is given for variability in inherent filtration including the panel of a fluoroscope. Delays have been permitted in the installation of interlock switches on x-ray therapy equipment when, in a private office the only door to the x-ray therapy room is immediately adjacent to and visible from the operator's location at the controls. Another type of delay allowed has been the installation of fluoroscopic timers in private offices of nonradiologists. Since many thousands of fluoroscopes in New York City were without such timers at the beginning of the program, it was virtually impossible to require them to be installed on all equipment immediately.

The notation "adequate operator protection" involves different criteria for different types of installations. For example, adequate operator protection in the case of a dental installation merely means that the exposure switch must be at the end of a sufficiently long electrical cord and the room so arranged that the operator may always be at least 6 feet away from the patient and the tube head, and away from the useful beam. In the case of a medical x-ray machine in a fixed location, the operator must be provided with a shielded booth or equivalent (fixed floor screen of adequate size), or the control may be in another room and the exposure switch must be so located that, when pressing the exposure switch, the operator cannot look around the edge of the wall of the booth at the patient. This is to avoid exposure of the operator to scattered radiation. In the case of mobile (bedside) equipment, the operator must have a long cord (as for dental installations), and also be provided with a protective apron.

---

[1] Hanson Blatz is director, and Daniel Lynch, assistant director, Office of Radiation Control, New York City Department of Health, N. Y.

From the foregoing, it can be seen that the method of applying standards to x-ray equipment and its use in New York City are not substantially different from those in other parts of the United States which have radiological health programs. However, the means of attaining compliance is unique to New York City.

Each Public Health sanitarian who is engaged in the inspection and surveillance program is a peace officer and thereby commissioned to serve a summons in cases of Health Code violations. Throughout the 9 years of this program, only one court summons has been served, but this was a special case involving violations of the Education Laws and the Criminal Code.

During the planning of the program, the Office of Radiation Control worked very closely with both the medical and dental professions to foster their cooperation. An informal arrangement was agreed upon, namely not to serve a summons to any member of a professional group employing x-ray equipment without first giving his professional organization the opportunity of interceding. In many cases, the County Medical Society or the local Dental District Society has written a letter to one of its members (and in some cases to nonmembers) after efforts to persuade the offender to correct deficiencies had failed. In every case but two, such letters have been effective and the offending professional has corrected all of the deficiencies listed in our report to him. In each of those two cases, the Health Commissioner issued a summons to the practitioner to appear at a private hearing to show cause why the x-ray equipment should not be sealed as constituting a public health hazard. In each case all of the deficiencies were either corrected or were being corrected by the date of the hearing and the hearing was cancelled. In effect, therefore, virtually 100-percent compliance with the more important requirements was attained although in some cases it has taken several years to attain such compliance. In many cases, we have considered minor deficiencies not sufficiently serious to take such drastic action but continued in an attempt to persuade offenders to make the necessary corrections.

Initially, when the inspection program was on a small scale, the survey results were hand tabulated from monthly forms. Special attention was given to beam collimation during chest radiography. It has been found that in many cases the primary beam exposed the gonads, and lenses of the eyes. Later, when compilation of the data was transferred to a computer system, this item of evaluation was extended to include satisfactory collimation for all techniques used; that is, for every combination of tube-to-film distance and film size routinely used.

The reason for considering these two criteria together is that over the years we have given equal emphasis in enforcement to adequate collimation of all fields. The criterion for a circular beam is that the beam diameter at the film be not over 2 inches greator than the diagonal dimension of the film used, except for dental films. For dental equipment the beam diameter at the cone tip must not be more than 3 inches.

The inspectors affix labels to each collimator listing the tube-to-film distance and film size combinations for which each may be used. Inspectors make spot checks of exposed films for cut-off of one or more corners to check on collimation under conditions of actual use.

Results

The findings of inspections conducted during three survey periods, 1959–1960, 1962–1963, and 1965–1966, are shown in table 1. The inspections made during the first two periods were initial inspections; those made during the 1965–1966, period included many installations that had been surveyed previously. The data for the 1965–1966 survey provide no breakdown with respect to second inspections, or to any corrections that may have been made following the initial inspection.

The original aim was to obtain information about uninspected installations. The data on the 1959–1960 and 1962–1963 inspections reflect this. At the outset there was a certain amount of selection according to age of the machine, as registered on forms filled out by the facility operators prior to the survey. Thus the earliest survey results were biased in the direction of greater emphasis on older machines.

Table 1. Results from inspections of x-ray machines

Type of installation and compliance item	1959–1960		1962–1963		1965–1966	
	Inspections	Percent in compliance	Inspections	Percent in compliance	Inspections	Percent in compliance
Mobile						
filtration	[illegible]	69.0	172	78.6	96	89.4
exposure switch	[illegible]	97.2	172	95.9	96	98.7
Dental						
filtration	2,716	66.3	2,377	80.9	2,356	95.9
exposure switch	2,716	95.0	2,377	83.1	2,356	95.3
beam limit	2,716	73.5	2,377	80.9	2,356	93.5
Medical radiographic						
filtration	1,648	75.0	1,179	83.1	958	94.8
exposure switch	1,648	37.0	1,179	45.2	958	79.2
beam limit	ᵃ1,061	34.0	ᵃ741	37.7	953	89.9
Fluoroscopic						
filtration	1,687	80.6	1,147	90.8	939	93.9
gloves	1,687	95.5	1,147	98.3	939	97.6
apron	1,687	91.5	1,147	92.8	939	97.1
beam limit	1,637	40.5	1,147	50.6	939	82.6
Therapy						
filter	127	80.3	165	93.3	121	97.5

ᵃ Chest x ray only.

The improvements seen in the 1965–1966 survey (tables 1 and 2) may reasonably be attributed to such factors as: 1) corrections following findings at the initial inspection, 2) newer machines, and 3) education associated with the activities of the Inspection Division.

The general trend of improvement in various major facility categories; hospital and clinic, private medical office, and dental, can be visualized readily by reference to table 2. Thus, it may be seen that the percentage of private medical units free from deficiencies outlawed by the City Health Code in 1958 increased from 8 to 73 percent; the corresponding improvement for dental units was from 47 to 89 percent.

As to the specific protective measures (table 1), the percentage of medical radiographic units considered to have adequate x-ray beam filtration increased from 75 percent to 95 percent; for fluoroscopes the improvement was from 81 percent to 94 percent; and for dental machines from 66 percent to 96 percent. With respect to the important factor of limitation of beam size to the area being examined, the following rates of improvement were observed: for medical radiographic equipment, adequate beam limitation was found in 90 percent in 1965–1966 as compared with 34 percent in 1959–1960; for fluoroscopic equipment the increase went from 40 percent to 88 percent; for dental equipment it rose from 73 percent to 94 percent. Corresponding improvement was also observed in protection of the operator in all types of facilities.

An interesting feature, as shown in table 2, is the increase in the percentage of machines free of deficiencies. In the most recent survey, these were: dental, 89 percent; medical (office), 73 percent; and hospitals or clinics, 81 percent.

Table 2. Results from inspections of x-ray machines by type of x-ray facilityᵃ

Type of facility	1959–1960		1962–1963		1965–1966	
	Inspections	Percent in compliance	Inspections	Percent in compliance	Inspections	Percent in compliance
Hospital and clinic	(ᵇ)	(ᵇ)	1,357	54	401	81
Medical, private office (radiographic and fluoroscopic)	3,623	8	1,520	20	1,705	73
Dental	2,716	47	2,377	57	2,356	89

ᵃ Gross findings; inspected machine may have a deficiency in one or a combination of parameters.
ᵇ Not recorded.

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Summary and discussion

After the initial inspection of x-ray equipment in New York City was completed in 1959–1960, the results showed a preponderance of deficiencies which constituted violations of the Radiological Hazards Section of the Health Code of 1958. Physicians and dentists were notified of each violation and instructed how to make necessary changes.

Subsequent followup inspections and repeated instructions brought about a significant improvement. This is considered to have resulted in a sharply reduced exposure of patients and operators to unnecessary radiation during medical and dental examinations. The remaining deficiencies, however, are not insignificant and a continuing effort is being exerted to eliminate them.

Refinements in medical and dental radiology are continually being developed. When any technique has been proven to be effective in reducing radiation exposure, it is intended that it will be made mandatory under the Health Code.

Acknowledgments

Acknowledgment is gratefully given for the collection of data by the Radiation Inspection Division under the successive leadership of A. Africk, M. Rosenfeld, and B. S. Reich, and for the assembly and tabulation of the data by M. Smolens, special assistant. The 1965–1966 data represent a small part of the large mass of data processed by our Health Department's Division of Organization and Methods, and machine tabulated by the staff of the Bureau of Radiological Health, Public Health Service, Rockville, Md.

REFERENCE

(1) NATIONAL COMMITTEE ON RADIATION PROTECTION AND MEASUREMENTS. Medical x-ray protection up to three million volts, NCRP Report No. 26. National Bureau of Standards Handbook 76 (February 1961).

Technical Notes

Tritium in New York State Waters, 1965

Kurt Anderson[1]

The Bureau of Radiological Health of the New York State Health Department conducted a survey of tritium concentrations in various waters of New York State during 1965. Three parts of the study included sampling of major river systems and large lakes, intense sampling of the area near the first commercial fuels reprocessing plant, and sampling of the ground waters on Long Island.

Begemann and Libby (*1*) reported that naturally occurring tritium, which results from the interaction of cosmic rays with the upper atmosphere, produces a tritium concentration in rain of approximately 2.5×10^{-3} nCi/liter. The study was undertaken because it was felt that the weapons tests in the late 1950's and early 1960's may have significantly increased environmental tritium levels and that there would be significant increases from nuclear facilities in the future.

Analytical procedures

The State Health Department's Radiological Laboratories did not have the capability for tritium counting at the time of this study and analyses were performed by two commercial laboratories; Tracerlab Incorporated, and Isotopes Incorporated.

The Tracerlab procedure used liquid scintillation counting with no sample refinement. The minimum detectable limit was taken as 1.6 nCi/liter with an associated counting error of ±50 percent. Any samples containing less than 1.6 nCi/liter were reported as <1.6 nCi/liter.

The Isotopes Incorporated procedure consisted of unmodified liquid scintillation counting to determine the range of radioactivity. If the sample had a tritium concentration greater than 9.6 nCi/liter, only liquid scintillation counting was used with a counting error of ±10 percent. For samples containing 0.16 to 9.6 nCi/liter, the sample was enriched by electrolytic means, then gas counted. The associated error with this method was ±10 percent. For samples less than 0.16 nCi/liter, the sample was first electrolytically enriched, and then further concentrated by a "dry box" distillation method, followed by gas counting. Use of this procedure allows tritium concentration determinations for samples containing 3.2×10^{-3} nCi/liter ±10 percent.

Statewide study

The State's major rivers, creeks, and lakes were sampled to see what variations in tritium content occurred throughout the State (figure 1). Since most tritium in the atmosphere from nuclear weapons probably reaches the surface waters in precipitation, one would expect that running water, such as in creeks and rivers (made up of recent precipitation runoff) may be higher in tritium than large, deep lakes that contain older water, providing greater dilution.

Nuclear Fuels Services study

Nuclear Fuels Services, a fuels-reprocessing plant, releases several curies of tritium a day (*2*). Before the plant went into operation, all creeks, lakes, and water supplies within 10 miles of the plant were sampled, some more than once

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[1] Mr. Anderson is assistant sanitary engineer, Bureau of Radiological Health, New York State Department of Health, Albany, N.Y.

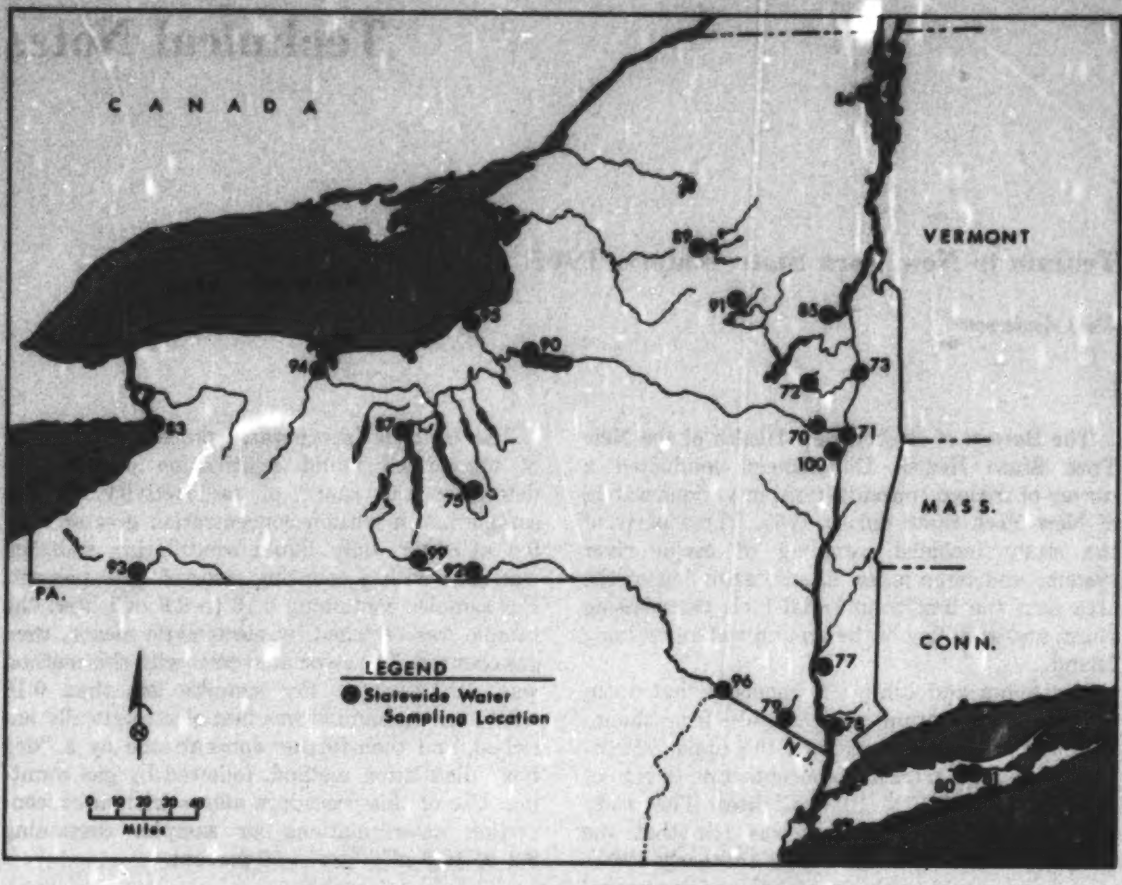

Figure 1. Sampling locations in New York State waters

(figure 2). This study established a background level for future evaluation of the plant's influence on the area.

Long Island well waters

Six wells each in Nassau and Suffolk counties were sampled for tritium (figure 3). It was felt that it might be possible to date the water to determine rainwater infiltration rates. Infiltration rates would be very helpful to water supply managers for predicting the abundance or scarcity of water in relation to rainfall.

Discussion of results

In the statewide study the samples taken from Lakes Seneca, Cayuga, Ontario, and Erie had tritium concentrations less than 1.3 nCi/liter, while Lake George and Lake Champlain had levels above that amount (table 1). It is felt that large lakes do have lower levels of tritium than streams, but lake samples should not be taken next to the shore as these samples were taken. Shore samples may indicate the influence of surface runoff and not reflect the average concentration of tritium in the lake as a whole. Further study is necessary to ascertain the correctness of this hypothesis. The overall average value for lakes and rivers is approximately 1.6 nCi/liter. This level is considerably higher than the "natural" level of 2.5×10^{-2} nCi/liter and shows the contribution of fallout.

The creeks and other water bodies sampled around the fuels reprocessing plant had an average tritium concentration of approximately 1.9 nCi/liter. The concentrations varied from less than

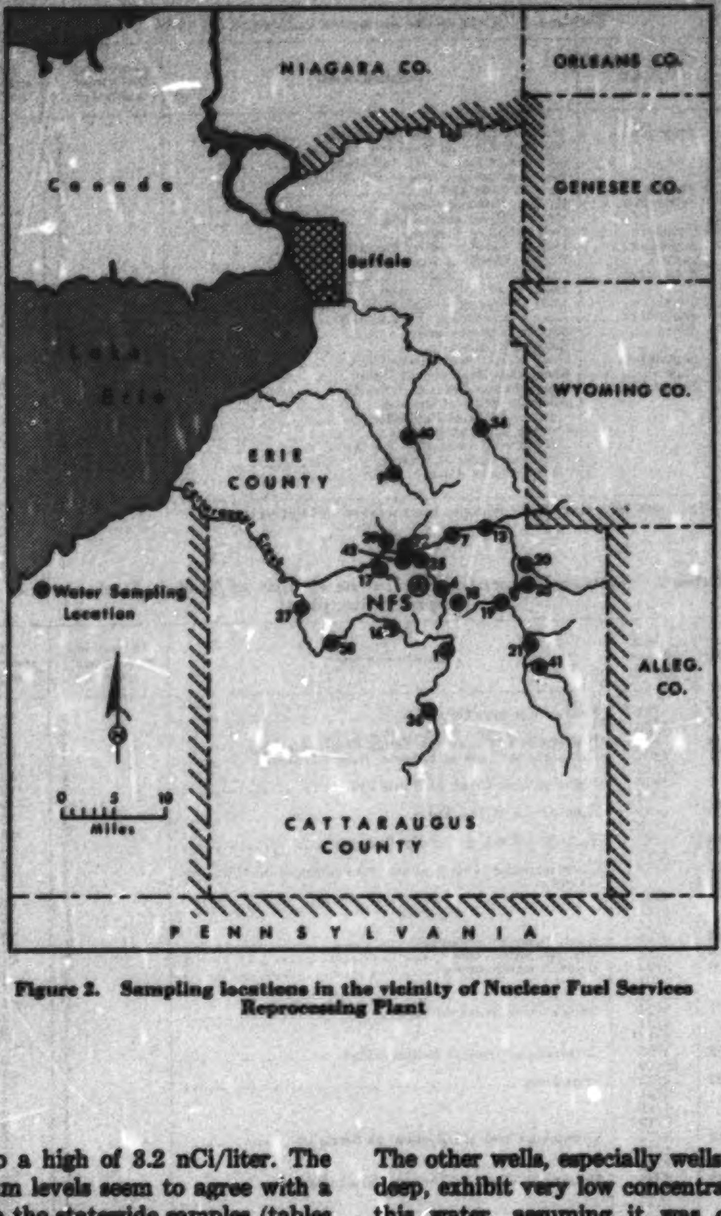
NIAGARA CO.
ORLEANS CO.
Canada
GENESEE CO.
Buffalo
Lake Erie
WYOMING CO.
ERIE COUNTY
Cattaraugus Creek
Water Sampling Location
NFS
ALLEG. CO.
0 5 10
Miles
CATTARAUGUS COUNTY
PENNSYLVANIA

Figure 2. Sampling locations in the vicinity of Nuclear Fuel Services Reprocessing Plant

1.6 nCi/liter up to a high of 3.2 nCi/liter. The variations in tritium levels seem to agree with a similar variation in the statewide samples (tables 1 and 2). A value for background tritium concentration probably lies between 1.6 and 3.2 nCi/liter.

The wells on Long Island exhibit very low concentrations of tritium compared to surface waters (table 3). The one exception, Flanders, is a shallow well and the time necessary for surface water intrusion is probably short (only a few years). The other wells, especially wells 200 feet or more deep, exhibit very low concentrations. The age of this water, assuming it was originally free of weapons-produced tritium and contained 2.5 × 10^{-2} nCi/liter, would be approximately 30 or more years old.

Generally speaking, tritium levels in surface waters of New York State may have increased by a factor of 70 to 100 times since the development of nuclear weapons, while deep well water has not yet been affected.

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Table 1. State-wide samples collected in 1966

Site number	Collection date (1966)	Location of site	Laboratory performing analysis [a]	Tritium concentration (nCi/liter) [b]
76	September	Mohawk River at Rt. 146 bridge	T	2.0 ±0.6
77		Mohawk River at Vischer Ferry Dam	T	2.5 ± .6
78		Glowegee Creek at Rt. 147 bridge	T	2.0 ± .6
79		Kayaderosseras Creek at Rt. 50 bridge	T	3.0 ± .7
80	August	Cayuga Lake at Ithaca	T	1.3 ± .1
81	September	Hudson River at Beacon	T	<1.6
82		Hudson River at Ossining	T	3.4 ± .7
83	October	Indian Kill at Tuxedo	T	<1.6
84	September	Peconic Creek at Wm. Floyd Parkway	T	<1.6
85	May	Peconic Creek at Wading River Road	I	.71 ± .04
86	September	Lake Erie at Buffalo	I	1.3 ± .1
87		Lake Ontario at Rochester	I	.90 ± .04
88	June	Lake George at Village of Lake George	I	1.0 ± .1
89	September	Lake Champlain at Plattsburgh	I	2.1 ± .1
90	June	Seneca Lake at Geneva	I	.84 ± .04
91		[illegible] Lake	I	2.5 ± .1
92	September	Oneida Lake near Cicero Center	I	2.0 ± .1
93	June	Sacandaga Reservoir at Dam	I	2.5 ± .1
94	September	Susquehanna River at Waverly	T	<1.6
95		Allegheny River at Onoville	T	<1.6
96		Genesee River at Rochester	T	<1.6
97		Oswego River at Oswego	T	<1.6
98		Delaware River at Port Jervis	T	<1.6
99		Chemung River at Elmira	T	2.5 ± .7
100		Rain water at Albany	I	1.5 ± .1

[a] T—Tracerlab Incorporated. I—Isotopes Incorporated. [b] Counting error.

Table 2. Tritium concentrations in the vicinity of Nuclear Fuels Services reprocessing plant

Site number	Date collected (1966)	Location of site	Laboratory performing analysis [a]	Tritium concentration (nCi/liter) [b]
1	3/22	Beaver Meadows Creek	I	2.5±0.1
	5/26		I	2.7± .1
4	3/23	Buttermilk Creek at Fox Valley Road	I	2.0± .1
7	4/21	Cattaraugus Creek at Bigelow Bridge	I	3.0± .2
	7/12		T	<1.6
9	3/23	Eighteen Mile Creek at Route 219	I	1.9± .1
	4/26		I	2.7± .1
13	4/21	Elton Creek at The Forks	I	3.0± .1
	7/12		T	<1.6
15	3/23	East Otto Creek at County Route 75	I	2.0± .1
	4/21		I	2.8± .1
17	3/23	Connoisarauley Creek above confluence of Cattaraugus Creek	I	3.4± .1
	4/21		I	2.9± .1
	5/17		T	3.2± .6
	7/12		T	<1.6
18	7/12	West Valley water supply	T	<1.6
19	7/12	Machias water supply	T	<1.6
20	3/23	Delevan water supply	I	1.4± .04
	4/21		I	1.5± .1
	5/17		T	<1.6
21	3/24	Ischua Creek at Route 16	I	2.0± .1
	4/21		I	3.1± .1
	5/17		T	<1.6
32	3/23	Cattaraugus Creek at Felton bridge	I	2.8± .1
	10/29		T	<1.6
33	3/23	Lime Lake	I	1.6± .1
	4/21		I	1.7± .1
	5/18		I	2.1± .1
	7/12		T	2.1± .6
34	3/23	Cazenovia Creek (E. Branch) at Route 16	I	1.6± .1
	4/21		I	3.2± .2
	7/12		T	<1.6
35	3/23	Buttermilk Creek at Thomas Corners Road	I	3.3± .1
	4/21		I	3.2± .2
	5/17		T	<1.6
	10/29		T	<1.6
36	5/17	Great Valley Creek at Route 242	I	2.8± .1
	7/13		T	<1.6
37	4/21	S. Branch Cattaraugus Creek at Forty Bridge	I	2.6± .1
38	4/21	S. Branch Cattaraugus Creek at Village of Otto	I	3.1± .2
	5/18		I	2.3± .1
	7/12		T	1.9± .6
39	5/17	Spooner Creek, Town of Concord at Bear Valley Road	I	2.0± .1
	7/13		T	2.1± .6
40	7/13	W. Branch Cazenovia Creek at Glenwood	T	2.0± .6
41	7/14	Franklinville Water Supply Reservoir	T	1.7± .6
42	12/16	Cattaraugus Creek at Springville Dam	T	<1.6
	12/23		T	<1.6
	12/30		T	1.8± .6

[a] Tracerlab Incorporated. I—Isotopes Incorporated. [b] Counting error.

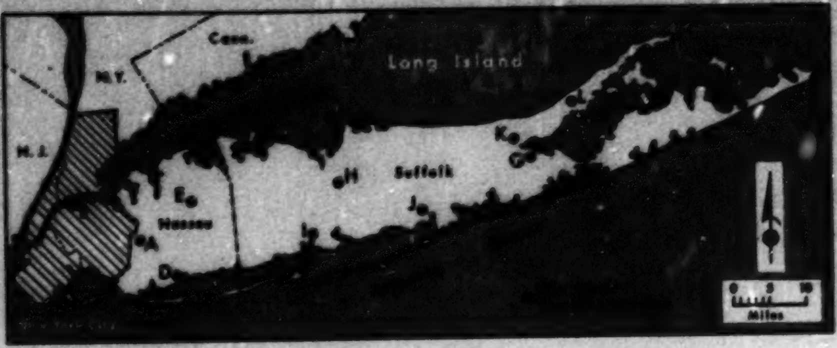

Figure 3. Long Island well water sampling locations

Table 3. Tritium concentrations in Long Island well water, July 1965[a]

Site	Location of site	Depth of well from surface (feet)	Tritium concentration (nCi/liter)[b]
A	Garden City	30	$9.0\times10^{-3}\pm0.3\times10^{-3}$
B	Sands Point	214	$1.3\times10^{-3}\pm.1\times10^{-3}$
C	Sands Point	140	$.20\pm.01$
D	Village of Freeport	507	$.6\times10^{-3}\pm.1\times10^{-3}$
E	Jericho Water District	600	$.4\times10^{-3}\pm.1\times10^{-3}$
F	Long Beach City	1,378	$.4\times10^{-3}\pm.1\times10^{-3}$
G	Flanders	28	$1.6\pm.1$
H	Nesconset	87	$.23\pm.03$
I	Bayshore	44	$.9\times10^{-3}\pm.1\times10^{-3}$
J	Brookhaven	58	$6.7\times10^{-3}\pm.3\times10^{-3}$
K	Riverhead	115	$5.4\times10^{-3}\pm.3\times10^{-3}$
L	Cutchogue	42	$.13\pm.01$

[a] All analyses were performed by Isotopes Incorporated.
[b] Counting error.

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(*1*) BEGEMANN, F. and W. F. LIBBY. Continental water balance, ground water inventory and storage times, surface ocean mixing rates and worldwide circulation patterns from cosmic ray and bomb tritium. Geochim et Cosmochim Acta 12:277 (1957).

(*2*) NUCLEAR FUEL SERVICES. Safety Analysis, Spent Fuel Processing Plant Nuclear Fuel Services, Part B (1962).

Surveillance for Krypton-85 in the Atmosphere

N. Irving Sax, Robert R. Reeves, and *J. David Denny*[1]

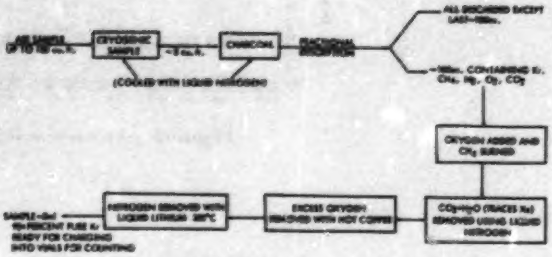
Today, the major source of atmospheric krypton-85 is nuclear fission for the production of power (*1*). Very little is released to the atmosphere at the time of fission but when the fuel elements are reprocessed, it is not unusual for 10^3 to 10^4 curies of krypton-85 to be released through the stack of a reprocessing plant to the surrounding atmosphere in a given day.[2]

The purpose of this study was to develop a practical technique for conducting routine surveillance for atmospheric krypton-85.

Procedure

A simple, inexpensive method was developed for field sampling using plastic bags which could readily be filled in the field in less than 2 minutes with up to 8 ft³ of air each, via a standard battery-powered automobile vacuum cleaner. The bagged samples were inserted into ordinary cardboard cylinders and shipped to Albany for processing where they are emptied into a cryogenic collector for analysis, as described below.

In the laboratory, the air sample from a bag or the ambient air in the laboratory, is taken directly into a cryogenic collector using a 5 Å molecular sieve as an adsorbent at liquid nitrogen temperature. The sample is transferred to a vacuum rack by desorbing it from the molecular sieve and readsorbing on charcoal contained within the rack and cooled with liquid nitrogen (*2*). The sample is then fractionally desorbed from the charcoal. The first part of the sample (less than 1 percent) is discarded since it contains little krypton and the remainder, about 100 cc, is purified by physical and chemical means. The final sample, about 2 cc of gas (STP), is thereby concentrated to at least 90 percent krypton from an initial total air sample of about 100 ft³ containing about 10^{-4} percent krypton by volume. The purification steps to obtain the final sample are shown in figure 1.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~100cc. CONTAINING Kr, CH₄, N₂, O₂, CO₂
OXYGEN ADDED AND CH₄ BURNED
CO₂+H₂O (TRACES Xe) REMOVED USING LIQUID NITROGEN
EXCESS OXYGEN REMOVED WITH HOT COPPER
NITROGEN REMOVED WITH LIQUID LITHIUM 20°C
SAMPLE ~2cc 90 PERCENT PURE Kr READY FOR CHARGING INTO VIALS FOR COUNTING

Figure 1. Block diagram of purification for atmospheric krypton

The sample is counted for krypton-85 beta-particles using a standard liquid scintillation-type counter with a solid scintillant instead of a liquid. A glass vial which contains p-terphenyl in polyvinyl toluene in the form of shavings is evacuated and filled with a measured amount of the sample and then counted (*3*). Since the efficiency of counting disintegrations of krypton-85 can be measured by using a krypton standard, the percent of krypton-85 can be determined and the atom percent of krypton-85 in the total krypton can be calculated. Assuming a fixed concentration of krypton in the atmosphere (1.14 ppm), the specific activity of krypton-85 can then be obtained.

Results

The results obtained during the period, April 1, 1967 to March 31, 1968, are shown in figure 2 and table 1. In the period, April through August 1967, relatively large samples (>100 cubic feet of air) were taken and only the purest krypton samples were retained. These samples

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[1] Mr. Sax is an associate research scientist in charge of the Radiological Sciences Laboratory, Division of Laboratories and Research, New York State Department of Health; Dr. Reeves is on the staff of Rensselaer Polytechnic Institute; and Captain Denny is in the U.S. Army stationed at Ft. McClellan, Ala.

[2] Communication from Nuclear Fuel Services, Inc., West Valley, N.Y.

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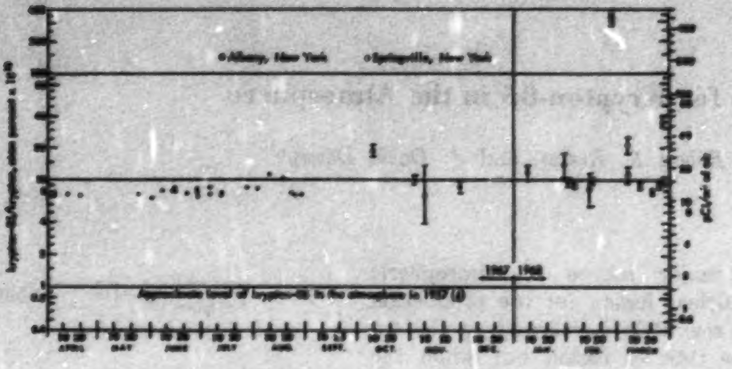

Figure 2. Atmospheric krypton-85 measurements

Table 1. Krypton in the atmosphere

Sampling location	Date of sample collection	Concentration* (pCi/m³)
	1967	
N.Y., Albany	4/ 5	11.8± 5%
	4/ 5	12.1± 5%
	4/13	11.7± 5%
	4/20	11.6± 5%
	5/25	11.7± 5%
	6/ 1	11.0± 5%
	6/ 8	12.3± 5%
	6/15	12.9± 5%
	6/15	12.7± 5%
	6/22	12.1± 5%
	6/29	12.4± 5%
	6/29	10.9± 5%
	7/ 7	12.7± 5%
	7/ 7	11.9± 5%
	7/13	11.9± 5%
	7/13	12.1± 5%
	7/28	13.2± 5%
	8/ 2	12.8± 5%
	8/11	17.7± 5%
	8/17	16.4± 5%
	8/22	11.9± 5%
	8/23	11.5± 5%
	8/28	11.5± 5%
	10/10	29 ± 2%
	11/ 3	16 ± 2%
	11/ 9	11 ± 10%
	11/30	13 ± 2%
	1968	
N.Y., Albany	1/ 9	16 ± 3%
	1/30	21 ± 6%
	1/31	15 ± 1%
	2/ 5	14 ± 1%
N.Y., Springville	2/14	12 ± 5%
N.Y., Albany	2/15	15 ± 1%
N.Y., Springville	2/27	880 ±100%
	2/27	480 ± 40%
	3/ 7	43 ± 9%
	3/ 7	17 ± 4%
N.Y., Albany	3/14	14 ± 1%
	3/21	12 ± 1%
	3/25	14 ± 1%
	3/28	15 ± 1%
N.Y., Springville	3/28	54 ± 7%

* One sigma analytical error.

were given long counts with frequent standardization. The precision of these results is better than ±5 percent based upon a consideration of overall analytical error and confirmed by a series of duplicate samples.

Several samples were taken about 5 miles north of the reprocessing plant. Some of these samples contained relatively high levels of krypton-85, up to 30 times the concentrations regularly measured. The limits of error on all measurements taken during and since October have been estimated and included as error bars on the graph.

Discussion

The present concentration of krypton-85 in the atmosphere is about 11 pCi/m³ which is minor in terms of population health hazard (*1*). It is, however, released in clouds from reprocessing plants so that considerably higher levels can periodically be observed until sufficient mixing with the atmosphere has occurred.

The surveillance described above was for the purpose of developing a simple, inexpensive, and reasonably sensitive environmental monitoring technique for krypton-85 in the atmosphere. One or two 8-cubic foot air samples collected by this technique are enough for an analysis to an analytical precision of ±10 percent.

Current atmospheric concentrations of krypton-85 of about 11 pCi/m^3 have been measured and occasional transients up to 2 times higher have been observed. It should be noted that the increase in the background krypton-85 in the atmosphere from April 1, 1967 to March 31, 1968 was less than 10 percent (figure 2). Additional air samples taken about 5 miles to the north of a reprocessing plant have shown much higher levels (up to 450 pCi/m^3) as might be anticipated.

Acknowledgement

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SECTION I. MILK AND FOOD

Milk Surveillance, November 1968

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long term concentration trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN), sponsored by the Bureau of Radiological Health and the Bureau of Community Environmental Management, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments have also initiated local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations
Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

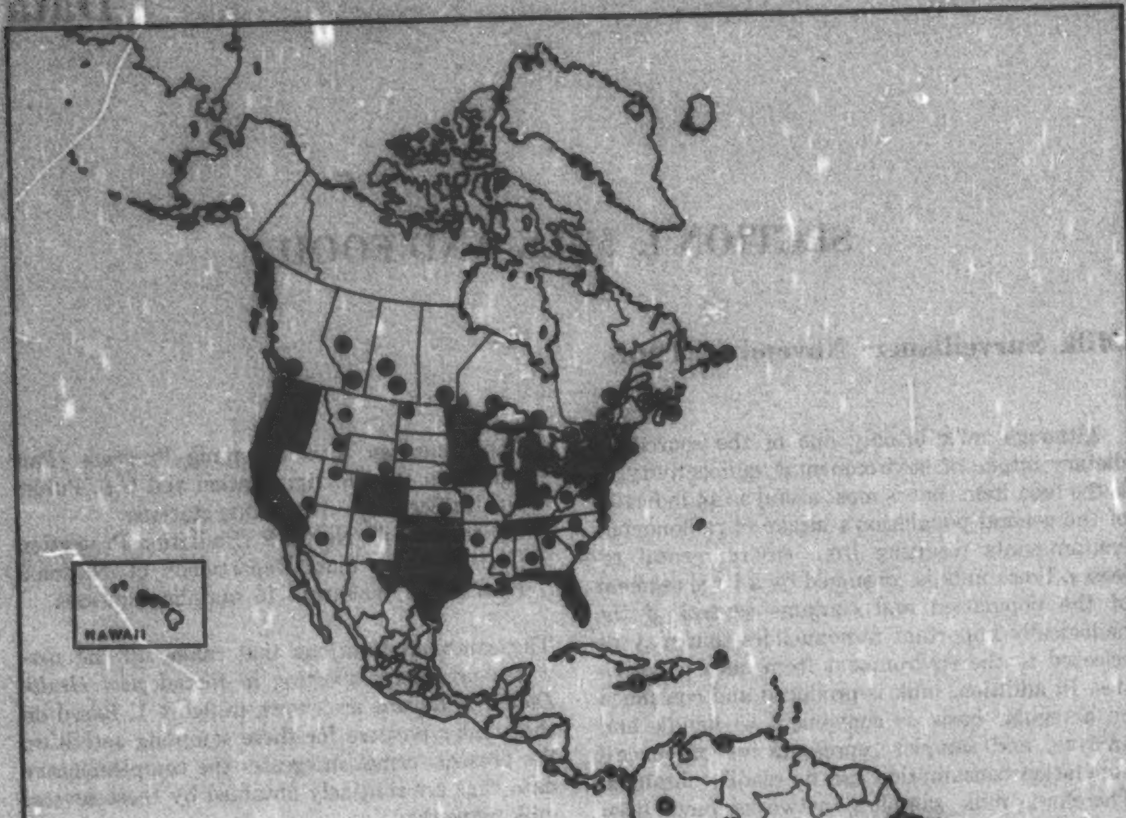
HAWAII
LEGEND:
● Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
○ Pan American Health Organization Sampling Stations
▨ States Presently Reported
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere

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metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation expressed in terms of 2-standard deviations for these concentrations are 1.16 ± 0.08 g/liter and 1.51 ± 0.21 g/liter for calcium and potassium, respectively. These figures are averages of data from the PMN for the period, May 1963–March 1968 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined in the literature (*4*).

The most recent study was conducted in the spring of 1967, with 40 laboratories participating in an experiment on milk samples containing known concentrations of strontium-90, iodine-131, and cesium-137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 of these laboratories participated in the experiment.

In the majority of cases, the results for the laboratories fell within the 3-standard deviation limits considered appropriate for the various analyses. Several results were outside the 3-standard deviation limits and the most deviant of these represented biases from the expected values of 20 to 30 percent (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis not only varies among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over the time periods involved and sampling frequency is not critical. For the case of the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation will also reflect whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision 2-standard deviation
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter

For iodine-131, cesium-137, and barium-140 there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance for the use of Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8, 9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1 liter per day intake of milk one can utilize the graded approach of daily intake on the basis of radionuclide content

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/yr)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/yr)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)	Range II (pCi/day)	Range III (pCi/day)
Strontium-89	Bone	1.5	0.5	[b] 2,000	0–200	200–2,000	2,000–20,000
	Bone marrow	.5	.17				
Strontium-90	Bone	1.5	.5	[b] 200	0–20	20–200	200–2,000
	Bone marrow	.5	.17				
Iodine-131	Thyroid	1.5	.5	100	0–10	10–100	100–1,000
Cesium-137[c]	Whole body	.5	.17	3,600	0–360	360–3,600	3,600–36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.

[b] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[c] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Protective Action Guides *(10, 11)*

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentra-

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first year total dose not to exceed 15[a,b]	5 in first yr; total dose not to exceed 5[a,b]	[c] 1,110,000
Strontium-90	Bone marrow			[c] 51,000
Cesium-137	Whole body			[c] 730,000
Iodine-131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered.

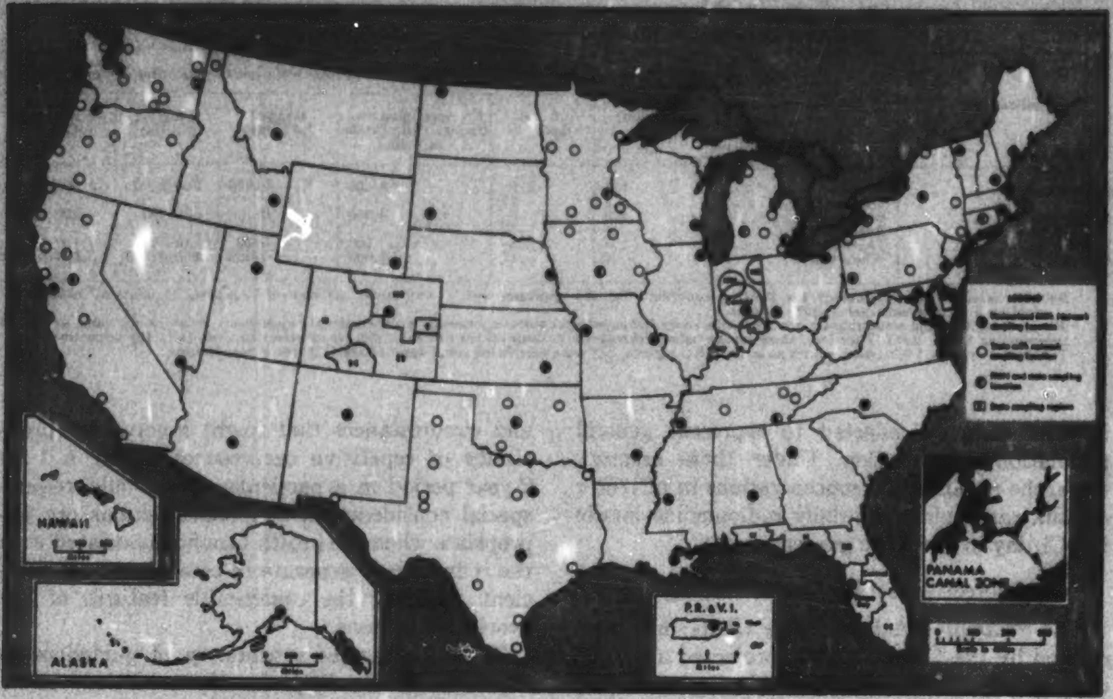

Figure 2. State and PHS sampling locations in the United States

tion from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in a retrospective manner.

Data reporting format

Table 8 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports.* (The relationship between the PMN stations and State stations is shown in figure 2.) The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-month average, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium-90, iodine-131, and cesium-137 for November 1968 and the 12-month period, December 1967 to November 1968. Except where noted the monthly average represents a single sample for the sampling station. Strontium-89 and barium-140 data have been omitted from table 3 since levels at the great majority of the stations

Table 3. Concentrations of radionuclides in milk for November 1968 and 12-month period, December 1967 through November 1968

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery	P	7	9	0(4)	0	14(4)	12
Alaska:	Palmer	P	0	5	0(3)	0	11(3)	14
Ariz:	Phoenix	P	0	1	0(4)	0	0(4)	2
Ark:	Little Rock	P	18	21	0(4)	0	11(4)	19
Calif:	Sacramento	P	0	2	0(3)	0	0(3)	6
	San Francisco	P	0	1	0(4)	0	0(4)	3
	Del Norte	P	26	20	0	0	26	24
	Fresno	P	3	1	0	0	11	6
	Humboldt	P	5	4	0	0	12	11
	Los Angeles	P	3	1	0	0	0	6
	Mendocino	P	0	2	0	0	0	4
	Sacramento	P	5	2	0	0	0	5
	San Diego	P	0	0	0	0	11	5
	Santa Clara	P	0	0	0	0	12	7
	Shasta	P	5	4	0	0	11	5
	Sonoma	P	0	2	0	0	0	5
Colo:	Denver	P	8	4	0(4)	0	8(4)	7
	West	R	(e)		(e)	(e)	(e)	(e)
	Northeast	R	(e)		(3)	1	(3)	(e)
	East	R	(e)		NS	(e)	NS	(e)
	Southeast	R	(e)		NS	(e)	NS	(e)
	South Central	R	(e)		NS	(e)	NS	(e)
Conn:	Hartford	P	9	10	0(5)	0	11(5)	11
	Central	R	8	7	0(5)	0	17(5)	19
Del:	Wilmington	P	7	10	0(4)	0	10(4)	8
D.C.:	Washington	P	9	10	0(4)	0	0(4)	6
Fla:	Tampa	P	10	8	0(3)	0	78(3)	67
	West	R	10	14	0	4	88	81
	North	R	11	15	0	0	65	53
	Northeast	R	9	9	0	2	114	95
	Central	R	9	9	15	3	98	88
	Tampa Bay area	R	8	8	0	0	77	73
	Southeast	R	10	9	0	2	117	105
Ga:	Atlanta	P	11	14	0(4)	0	10(4)	20
Hawaii:	Honolulu	P	5	4	0(4)	1	3(4)	4
Idaho:	Idaho Falls	P	6	6	0(4)	0	14(4)	9
Ill:	Chicago	P	7	9	0(4)	0	9(4)	10
Ind:	Indianapolis	P	7	8	0(4)	0	3(4)	7
	Northeast	P	14	9	0	0	15	13
	Southeast	P	12	11	0	0	18	12
	Central	P	10	8	0	0	0	9
	Southwest	P	8	9	0	0	0	13
	Northwest	P	10	9	0	0	14	12
Iowa:	Des Moines	P	6	7	0(4)	0	3(4)	7
	Iowa City	P	7	7	0	0	12	5
	Des Moines	P	7(4)	7	0(4)	0	4(4)	2
	Spencer	P	3	6	0	0	0	3
	Charles City	P	NS		NS		NS	
Kans:	Wichita	P	8	8	0(4)	0	2(4)	4
Ky:	Louisville	P	11	12	0(4)	0	4(4)	6
La:	New Orleans	P	20	20	0(3)	0	17(3)	22
Maine:	Portland	P	13	13	3(4)	1	31(4)	29
Md:	Baltimore	P	11	10	0(4)	0	4(4)	6
Mass:	Boston	P	9	13	0(4)	0	21(4)	24
Mich:	Detroit	P	8	9	0(4)	0	9(4)	13
	Grand Rapids	P	13	11	0(4)	0	12(4)	15
	Bay City	P	NS	4	NS	(e)	NS	6
	Charlevoix	P	NS	6	NS	(e)	NS	8
	Detroit	P	NA	4	(e) (4)	(e)	0(4)	4
	Grand Rapids	P	NA	5	(e) (4)	(e)	6(4)	5
	Lansing	P	4	4	(e) (3)	(e)	4(3)	2
	Marquette	P	NA	7	(e) (3)	(e)	37(3)	22
	Monroe	P	NA	3	(e) (3)	(e)	0	1
Minn:	Minneapolis	P	11	13	0(4)	0	15(4)	13
	Bemidji	P	15	15	0	0	25	22
	Mankato	P	5	6	0	0	0	0
	Rochester	P	12	9	0	0	0	0
	Duluth	P	17	19	0	0	30	30
	Worthington	P	7	6	0	0	(e)	(e)
	Minneapolis	P	9	12	0	0	13	15
	Fergus Falls	P	8	10	0	0	(e)	(e)
	Little Falls	P	9	9	0	0	14	14
Miss:	Jackson	P	16	17	0(4)	0	18(4)	15
Mo.:	Kansas City	P	5	8	0(5)	0	0(5)	5
	St. Louis	P	13	9	0(5)	0	2(5)	7
Mont:	Helena	P	4	5	0(3)	0	13(3)	8
Nebr:	Omaha	P	4	7	0(5)	0	0(5)	5
Nev:	Las Vegas	P	0	1	0(4)	0	0(4)	4
N.H.:	Manchester	P	10	14	0(4)	0	25(4)	25
N.J.:	Trenton	P	9	10	0(4)	0	0(4)	10
N. Mex:	Albuquerque	P	0	2	0(4)	0	0(4)	2

See footnotes at end of table.

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Table 2. Concentrations of radionuclides in milk for November 1968 and 12-month period December 1967 through November 1968—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
N.Y:	Buffalo[c]	P	7	9	0(5)	0	6(3)	10
	New York City[c]	P	9	12	0(4)	0	12(4)	14
	Syracuse[c]	P	8	9	0(4)	0	9(4)	6
	Albany	P	NA	7	NA	0	NA	(e)
	Buffalo	P	NA	7	NA	0	NA	(e)
	Massena	P	NA	10	NA	0	NA	23
	Newburgh	P	NA	10	NA	10	NA	(e)
	New York City	P	NA	10	NA	0	NA	21
	Syracuse	P	NA	7	NA	0	NA	(e)
N.C:	Charlotte[c]	P	12	15	0(4)	1	10(4)	11
N. Dak:	Minot[c]	P	12	11	0(4)	0	9(4)	13
Ohio:	Cincinnati[c]	P	8	9	0(4)	0	6(4)	8
	Cleveland[c]	P	8	10	0(5)	0	3(5)	8
Okla:	Oklahoma City[c]	P	9	10	0(3)	0	12(3)	5
	Oklahoma City	P	(f)		NA		NA	
	Enid	P	(f)		NA		NA	
	Tulsa	P	(f)		NA		NA	
	Lawton	P	(f)		NA		NA	
	Ardmore	P	(f)		NA		NA	
Oreg:	Portland[c]	P	9	8	0(5)	0	9(5)	15
	Baker	P	0	4	(e)	(e)	(e)	4
	Coos Bay	P	8	10	(e)	(e)	(e)	12
	Eugene	P	3	3	(e)	(e)	(e)	11
	Medford	P	3	3	(e)	(e)	(e)	10
	Portland composite	P	4	7	(e)	(e)	(e)	8
	Portland local	P	0	5	(e)	(e)	(e)	9
	Redmond	R	NA	4	(e)	(e)	10	4
	Tillamook	P	NA	10	(e)	(e)	30	25
Pa:	Philadelphia[c]	P	7	10	0(4)	0	9(4)	9
	Pittsburgh[c]	P	10	12	0(4)	0	13(4)	13
	Dauphin	P	9	8	0	0	12	17
	Erie	P	13	13	0	0	0	21
	Philadelphia	P	11	9	0	0	17	17
	Pittsburgh	P	7	12	0	0	15	15
R.I:	Providence[c]	P	10	11	0(4)	0	17(4)	19
S.C:	Charleston[c]	P	12	14	0(4)	0	24(4)	26
S. Dak:	Rapid City[c]	P	6	9	0(4)	0	9(4)	11
Tenn:	Chattanooga[c]	P	15	13	0(4)	0	9(4)	13
	Memphis[c]	P	11	12	0(4)	0	11(4)	5
	Chattanooga	P	11	12	0(4)	1	16(4)	17
	Clinton	P	14	13	0	2	28	21
	Knoxville	P	8	11	0(3)	4	12(3)	16
	Nashville	P	9	8	0(3)	1	0(3)	12
Tex:	Austin[c]	P	6	4	0(3)	0	0(3)	2
	Dallas[c]	P	6	8	0(4)	0	0(4)	0
	Amarillo	R	NA	4	NA	0	NA	0
	Corpus Christi	R	NA	4	NA	0	NA	0
	El Paso	R	NA	2	NA	0	NA	0
	Fort Worth	R	NA	7	NA	0	NA	0
	Harlingen	R	NA	3	NA	0	NA	0
	Houston	R	NA	11	NA	0	NA	14
	Lubbock	R	NA	4	NA	0	NA	0
	Midland	R	NA	3	NA	0	NA	0
	San Antonio	R	NA	4	NA	0	NA	0
	Texarkana	R	NA	12	NA	0	NA	12
	Uvalde	R	NA	3	NA	0	NA	0
	Wichita Falls	R	NA	10	NA	0	NA	0
Utah:	Salt Lake City[c]	P	4	6	0(4)	0	12(4)	12
Vt:	Burlington[c]	P	8	11	0(4)	0	14(4)	9
Va:	Norfolk[c]	P	8	11	0(5)	0	9(5)	9
Wash:	Seattle[c]	P	7	9	0(4)	0	22(4)	22
	Spokane[c]	P	8	7	0(4)	0	9(4)	10
	Benton County	R	0	0	0	0	17	6
	Deer Park	R	5	3	0	0	16	3
	Elma	R	7	5	0	0	23	20
	Franklin County	R	NS	0	NS	0	NS	(e)
	Moses Lake	R	2	1	0	0	(e)	(e)
	Pierce County	R	5	3	0	0	18	9
	Sandpoint, Idaho	R	12	8	0	0	32	23
	Skagit County	R	4	4	0	0	(e)	14
W.Va:	Charleston[c]	P	7	12	0(3)	0	8(3)	5
Wis:	Milwaukee[c]	P	6	8	0(5)	0	15(5)	11
Wyo:	Laramie[c]	P	5	4	0(4)	0	23(4)	9
CANADA								
Alberta:	Calgary	R	8	9	(f)		17	19
	Edmonton	R	8	8	(f)		18	22
British Columbia:	Vancouver	R	15	14	(f)		48	55
Manitoba:	Winnipeg	R	10	8	(f)		22	24
New Brunswick:	Fredericton	R	15	15	(f)		21	24

See footnotes at end of table.

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Table 3. Concentrations of radionuclides in milk for November 1968 and 12-month period, December 1967 through November 1968—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA—Continued								
Newfoundland:	St. John	R	16	21	(d)		33	42
Nova Scotia:	Halifax	R	12	13	(d)		21	24
Ontario:	Ft. William	R	18	16	(d)		25	20
	Ottawa	R	9	9	(d)		21	20
	Sault Ste. Marie	R	15	15	(d)		20	22
	Toronto	R	5	5	(d)		18	16
	Windsor	R	7	6	(d)		11	14
Quebec:	Montreal	R	8	10	(d)		22	21
	Quebec	R	12	13	(d)		20	20
Saskatchewan:	Regina	R	8	8	(d)		27	16
	Saskatoon	R	11	9	(d)		11	18
CENTRAL AND SOUTH AMERICA								
Columbia:	Bogota	P	0	0	0	0	0	0
Chile:	Santiago	P	0	0	0	0	0	0
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Kingston	P	5	6	0	0	117	110
Venezuela:	Caracas	P	0	0	0	0	0	0
Canal Zone:	Cristobal[c]	P	4	2	0(4)	1	20(4)	10
Puerto Rico:	San Juan[c]	P	0	4	0(3)	0	9(3)	0
PMN network average[f]			8	9	0	0	10	12

[a] P, pasteurized milk; R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—11 pCi liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter
Washington—15 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS pasteurized milk network stations denoted by footnote [c].

NA, no analysis.

NS, no sample collected.

for November 1968 were below the respective practical reporting levels. Table 4 gives monthly averages for those stations at which strontium-89 or barium-140 were detected.

Table 4. Strontium-89 and barium-140 in milk November 1968

Sampling location	Monthly average (pCi/liter)	
	Strontium-89	Barium-140
Nebr: Omaha (PMN)	7	
Canal Zone: Cristobal (PMN)	7	
Calif: Del Norte (State)		14
Humboldt (State)		19
Santa Clara (State)		17
Shasta (State)		15
Maine: Portland (PMN)		3(4)[a]
Mich: Detroit (PMN)		3(4)
Pa: Pittsburgh (PMN)		3(4)
Wisc: Milwaukee (PMN)		3(5)

[a] Number in parentheses indicates number of samples.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 26 pCi/liter in the United States for the month of November 1968 and the highest 12-month average was 21 pCi/liter (Little Rock, Ark.), representing 10.5 percent of the Federal Radiation Council radiation protection guide (table 1).

Cesium-137 monthly averages ranged from 0 to 117 pCi/liter in the United States for the month of November 1968 and the highest 12-month average was 100 pCi/liter (Southeast Florida), representing 3.0 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*18*) and Jamaica. Iodine-131 results for individual samples were generally below the practical reporting level. The following station averages reflect samples in which iodine-131 was detected: Central Florida, (State) 15 pCi/liter, 1 sample; Portland, Maine (PMN) 8 pCi/liter, 4 samples.

Acknowledgment

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Radiological Health Section
Division of Air, Occupational and
Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiation and Occupational Health Section
Division of Environmental Sanitation
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York Department of Health

Division of Occupational and Radiological
Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	July–October 1967	May 1968
Institutional Diet, *PHS*	April–June 1968	January 1969
Tri-City Diet, *HASL*	April–December 1967	June 1968

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Last presented
California	July–December 1967	December 1968
Coast Guard	1967	February 1969
Colorado River Basin	1967	December 1968
Florida	1967	February 1969
Minnesota	January–June 1968	February 1969
New York	June–December 1967	October 1968
Radiostrontium in Tap Water, *HASL*	January–June 1967	April 1968
Washington	July 1966–June 1967	August 1968

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

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Gross Radioactivity in Surface Waters of the United States, September 1968

Division of Pollution Surveillance
Federal Water Pollution Control Administration, Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Water Pollution Surveillance System currently operated by the Federal Water Pollution Control Administration. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the November 1968 issue of *Radiological Health Data and Reports*.

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity

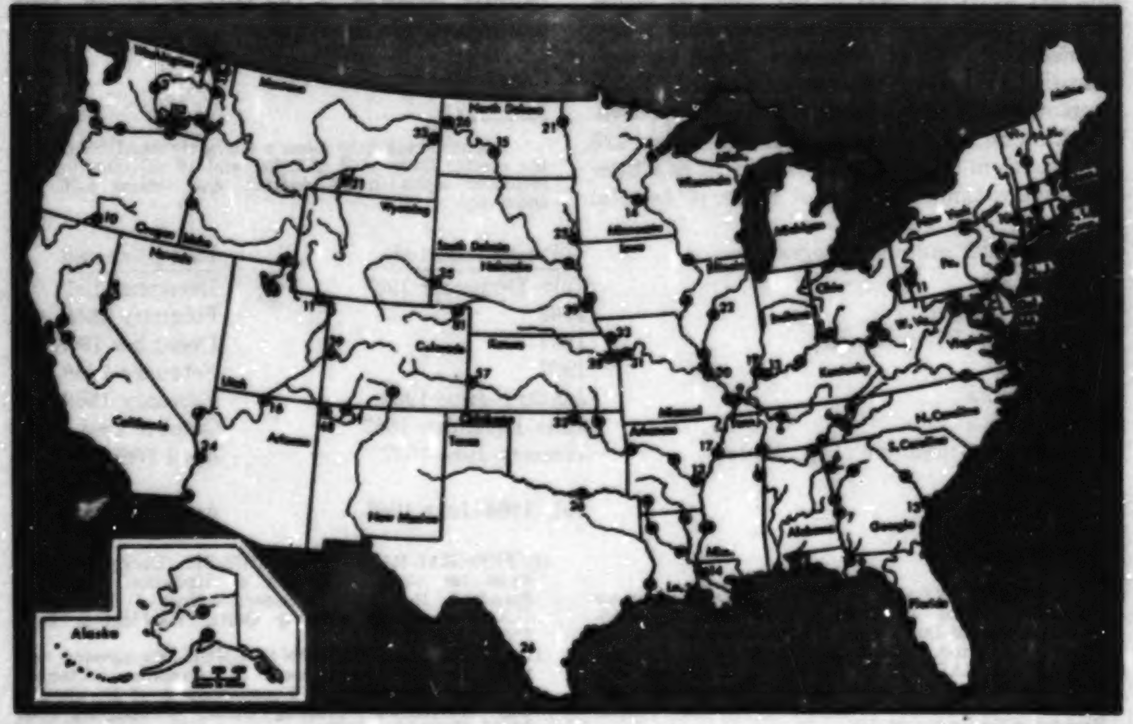
North Dakota
Wyoming
South Dakota
Nebraska
Colorado
Kansas
Utah
California
Arizona
New Mexico
Texas
Oregon
Idaho
Nevada
Kentucky
N. Carolina
S. Carolina
Georgia
Florida
Alabama
Ohio
Indiana
Pa.
Missouri
Arkansas
Miss.
La.
Alaska

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, September 1968

per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During September 1968, the following stations showed values in excess of 15 pCi/liter on alpha radioactivity for either suspended or dissolved solids:

Arkansas River; Coolidge, Kans.
North Platte River; Henry, Nebr.
South Platte River: Julesburg, Colo.

No station showed a gross beta radioactivity in excess of 150 pCi/liter during September 1968.

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Table 1. Radioactivity in raw surface waters, September 1968

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	0	2	2	3	8	11
Apalachicola River:						
Chattahoochee, Fla.	0	0	0	2	4	6
Arkansas River:						
Coolidge, Kans.	1	24	25	5	52	57
Ponca City, Okla.	2	6	8	7	28	35
Pendleton Ferry, Ark.	0	0	0	1	12	13
Atchafalaya River:						
Morgan City, La.	5	<1	5	24	12	36
Big Horn River:						
Hardin, Mont.	0	2	2	3	18	21
Big Sioux River:						
Sioux Falls, S. Dak.	1	1	2	3	20	23
Chattahoochee River:						
Columbus, Ga.	0	1	1	2	5	7
Clearwater River:						
Lewiston, Idaho	<1	0	<1	2	2	4
Clinch River:						
Kingston, Tenn.ᵃ	0	1	1	0	6	6
Colorado River:						
Loma, Colo.	1	11	12	9	30	39
Page, Ariz.	0	5	5	1	15	16
Parker Dam, Calif-Ariz.	0	5	5	3	21	24
Columbia River:						
Northport, Wash.	0	0	0	1	4	5
Wenatchee, Wash.	0	0	0	0	3	3
Pasco, Wash.ᵃ	0	1	1	54	59	113
Connecticut River:						
Wilder, Vt.	0	0	0	0	4	4
Enfield Dam, Conn.	0	0	0	3	6	9
Coosa River:						
Rome, Ga.	0	<1	<1	1	5	6
Cumberland River:						
Cheatham Lock, Tenn.	0	0	0	2	4	6
Escambia River:						
Century, Fla.	0	0	0	1	1	2
Great Lakes:						
Duluth, Minn.	0	0	0	1	3	4
Green River:						
Dutch John, Utah	0	2	2	1	10	11
Hudson River:						
Poughkeepsie, N.Y.	0	0	0	1	9	10
Illinois River:						
Peoria, Ill.	1	0	1	8	14	22
Kansas River:						
DeSoto, Kans.	2	2	4	11	17	28
Klamath River:						
Keno, Ore.	0	<1	<1	2	8	10
Merrimack River:						
Lowell, Mass.	0	0	0	2	6	8
Mississippi River:						
St. Paul, Minn.	0	1	1	1	13	14
E. St. Louis, Ill.	0	0	0	5	15	20
W. Memphis, Ark.	0	1	1	3	14	17
New Roads, La.	0	1	1	3	11	14
Missouri River:						
Williston, N. Dak.	2	2	4	8	18	26
Bismarck, N. Dak.	0	4	4	2	13	15
St. Joseph, Mo.	2	4	6	11	22	33
Missouri City, Mo.	1	2	3	8	23	31
Monongahela River:						
Pittsburgh, Pa.	0	0	0	1	10	11
North Platte River:						
Henry, Nebr.	<1	21	21	3	32	35
Ohio River:						
Cincinnati, Ohio	0	0	0	0	8	8
Evansville, Ind.	1	1	2	2	10	12
Cairo, Ill.	0	0	0	2	7	9
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	1	1	1	5	6
Platte River:						
Plattsmouth, Nebr.	6	3	9	22	17	39
Potomac River:						
Washington, D.C.	0	0	0	3	9	12
Rainy River:						
International Falls, Minn.	0	0	0	0	7	7
Red River, North:						
Grand Forks, N. Dak.	<1	2	2	3	18	21
Red River, South:						
Denison, Tex.	0	3	3	2	24	26
Rio Grande:						
Laredo, Tex.	2	3	5	10	16	26
San Juan River:						
Shiprock, N. Mex.	6	8	14	22	26	48
Savannah River:						
Port Wentworth, Ga.ᵃ	0	<1	<1	5	8	13
South Platte River:						
Julesburg, Colo.	1	41	42	5	76	81
Wabash River:						
New Harmony, Ind.	2	2	4	9	10	19
Yakima River:						
Richland, Wash.	<1	.1	1	1	5	6
Yellowstone River:						
Sidney, Mont.	4	3	7	18	15	33
Maximum	6	41	42	54	76	113
Minimum	0	0	0	0	1	2

ᵃ Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
HASL Fallout Network	July–December 1967	September 1968
HASL 80th Meridian Network	Calendar Year 1966	December 1968
Plutonium in Airborne Particulates	January–March 1968	January 1969

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1. Radiation Alert Network
November 1968

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. Compilation of the daily field estimates is reported elsewhere on a monthly basis (1). A detailed description of the sampling and analytical procedures was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during November 1968. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

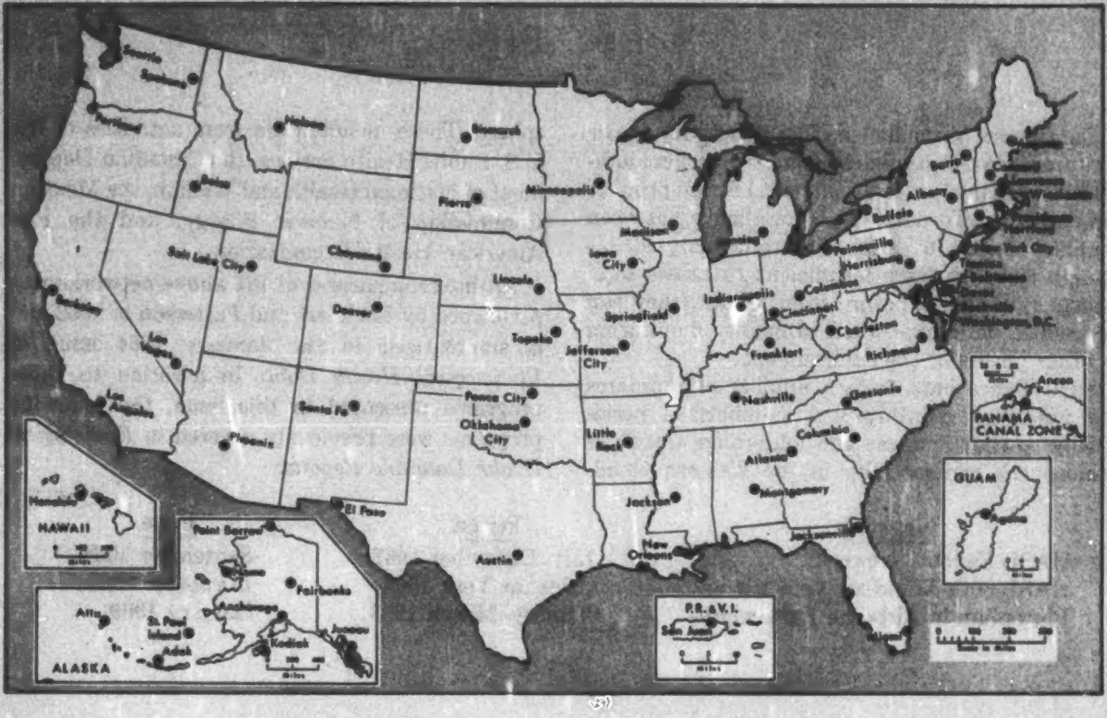
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Salt Lake City
Cheyenne
Lincoln
Berkeley
Denver
Topeka
Las Vegas
Los Angeles
Santa Fe
Phoenix
Ponca City
Oklahoma City
Madison
Lansing
Iowa City
Springfield
Jefferson City
Indianapolis
Columbus
Cincinnati
Charleston
Frankfort
Richmond
Buffalo
Albany
Barre
Augusta
Concord
Lawrence
Providence
Hartford
Painesville
Harrisburg
New York City
Trenton
Baltimore
Dover
Rockville
Washington, D.C.
Nashville
Gastonia
Columbia
Little Rock
Atlanta
Montgomery
Jackson
New Orleans
Jacksonville
Miami
Austin
El Paso
Honolulu
HAWAII
Point Barrow
Fairbanks
Anchorage
Juneau
Kodiak
Attu
St. Paul Island
Adak
ALASKA
P.R. & V.I.
San Juan
PANAMA CANAL ZONE
Ancon
GUAM
Agana
Scale in Miles

Figure 1. Radiation Alert Network sampling stations

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Table 1. Gross beta radioactivity in surface air and precipitation, November 1968

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation				
							Number of samples	Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average [a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	19	11	0	2	Sept 68	4	150	4	150	0
Alaska:	Adak	30	2	1	2	Feb 69	(c)				
	Anchorage	3	0	0	0	Oct 68	(c)				
	Attu Island	30	1	0	0	Mar 69	(c)				
	Fairbanks	(b)				Nov 68	(c)				
	Juneau	19	0	0	0	Dec 68	17	374	17	374	0
	Kodiak	17	1	0	0	Jan 69	(c)				
	Nome	(b)				July 68	(c)				
	Point Barrow	24	2	0	1	June 68	(c)				
	St. Paul Island	30	1	1	1	Aug 68	(c)				
Ariz:	Phoenix	17	14	1	7	Dec 68	(c)				
Ark:	Little Rock	(b)				Oct 68	(c)				
Calif:	Berkeley	18	1	0	0	Jan 69	5	55	5	55	2
	Los Angeles	(b)				July 68	(c)				
C.Z.:	Ancon	14	0	0	0	Jan 69	(c)				
Colo:	Denver	18	6	1	3	Jan 69	2	7	(d)		
Conn:	Hartford	18	1	0	0	Nov 68	7	98	5	71	0
Del:	Dover	16	1	0	0	Sept 68	(c)				
D.C.:	Washington	3	0	0	0	June 68	(c)				
Fla:	Jacksonville	19	10	0	1	Oct 68	2	10	2	10	11
	Miami	14	1	0	0	Nov 68	1	31	1	31	0
Ga:	Atlanta	17	2	1	1	Aug 68	3	165	3	165	145
Guam:	Agana	(b)				Sept 68	(e)				
Hawaii:	Honolulu	29	1	0	1	Mar 69	1	50	(d)		
Idaho:	Boise	19	9	0	3	Mar 69	4	26	2	26	16
Ill:	Springfield	19	3	1	1	June 68	3	42	0	0	(e)
Ind:	Indianapolis	17	8	0	1	Aug 68	6	109	6	109	61
Iowa:	Iowa City	17	7	0	1	Jan 69	3	35	3	35	0
Kans:	Topeka	18	2	0	1	Oct 68	4	28	4	28	2
Ky:	Frankfort	(b)				June 68	4	22	4	22	0
La:	New Orleans	16	1	0	0	June 68	4	98	(d)		
Maine:	Augusta	18	2	0	1	Dec 68	8	171	8	171	0
Md:	Baltimore	19	2	0	0	Nov 68	6	55	6	55	17
	Rockville	9	1	0	0	Mar 69	(e)				
Mass:	Lawrence	18	1	0	0	Sept 68	4	130	4	130	44
	Winchester	19	2	0	0	Feb 69	9	184	9	184	0
Mich:	Lansing	17	4	0	2	Mar 69	6	82	6	82	151
Minn:	Minneapolis	19	1	0	0	Sept 68	5	22	5	22	3
Miss:	Jackson	19	3	0	1	Dec 68	4	96	2	57	70
Mo:	Jefferson City	18	1	0	1	Aug 68	6	123	6	123	0
Mont:	Helena	15	5	0	2	Feb 69	4	4	4	4	5
Nebr:	Lincoln	18	4	0	2	Aug 68	3	27	3	27	18
Nev:	Las Vegas	17	2	0	1	Nov 68	(c)				
N.H.:	Concord	17	1	0	0	June 68	(c)				
N.J.:	Trenton	18	3	0	1	Dec 68	4	92	4	92	29
N. Mex:	Santa Fe	17	10	0	1	Feb 69	4	22	3	19	3
N.Y.:	Albany	14	3	0	1	Aug 68	8	80	8	80	38
	Buffalo	16	1	0	0	Jan 69	(c)				
	New York City	17	1	0	1	Feb 69	(c)				
N.C.:	Gastonia	16	15	1	4	Jan 69	2	18	(d)		
N. Dak:	Bismarck	16	4	0	1	June 68	3	9	3	9	0
Ohio:	Cincinnati	(b)				Sept 68	(c)				
	Columbus	15	5	0	1	Dec 68	7	101	0	0	(e)
	Painesville	20	1	0	1	Nov 68	10	12	10	12	6
Okla:	Oklahoma City	18	1	0	1	Mar 69	6	135	6	135	0
	Ponca City	20	4	0	1	Nov 68	6	91	6	91	0
Oreg:	Portland	17	1	0	0	Aug 68	13	89	13	89	7
Pa:	Harrisburg	10	3	0	1	Aug 68	(c)				
P.R.:	San Juan	(b)				Dec 68	(c)				
R.I.:	Providence	17	1	0	0	Mar 69	7	108	7	108	47
S.C.:	Columbia	14	3	0	1	Feb 69	5	106	5	106	39
S. Dak:	Pierre	19	10	2	5	Dec 68	(c)				
Tenn:	Nashville	13	1	0	1	Mar 69	7	154	7	154	6
Tex:	Austin	18	9	1	3	Sept 68	4	85	(d)		
	El Paso	15	9	0	3	June 68	(c)				
Utah:	Salt Lake City	20	4	0	1	July 68	8	40	6	38	9
Vt:	Barre	15	3	0	1	Oct 68	9	112	9	112	0
Va:	Richmond	11	1	0	0	Oct 68	2	24	2	24	14
Wash:	Seattle	15	0	0	0	Oct 68	11	88	(d)		
	Spokane	17	1	0	1	Sept 68	2	6	2	6	2
W. Va:	Charleston	9	1	0	1	Feb 69	10	49	9	45	12
Wis:	Madison	19	1	0	1	Oct 68	6	41	6	41	57
Wyo:	Cheyenne	18	7	1	3	Nov 68	2	14	2	14	13
Network summary		1,112	15	0	1		2	68	6	74	21

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] Indicates no report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were reported.

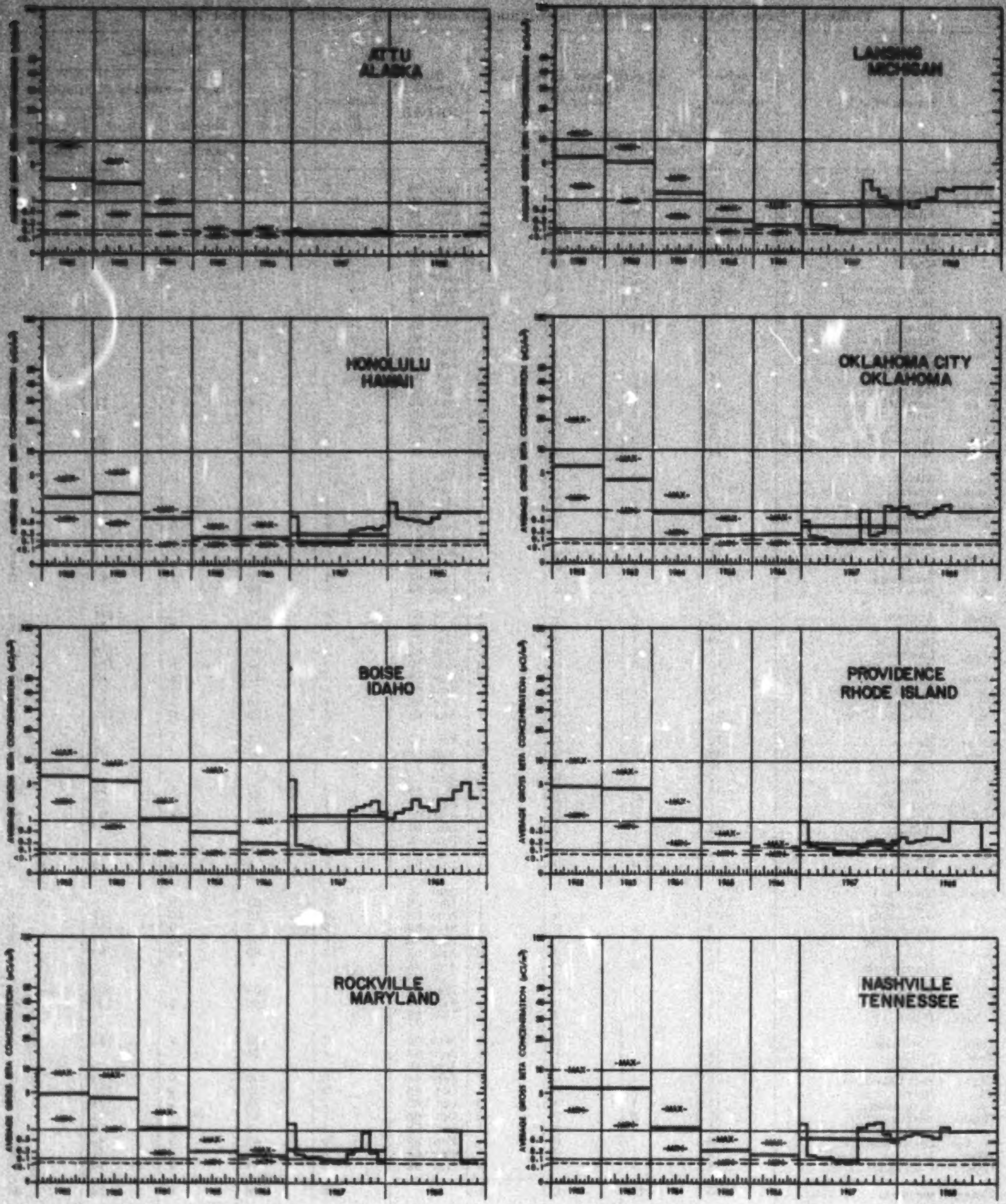

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, November 1968

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2. Canadian Air and Precipitation Monitoring Program,[1] November 1968

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the April 1968 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for November 1968 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, November 1968

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	30	0.1	0.0	0.0	NA	NA
Coral Harbour	30	.1	.0	.1		
Edmonton	30	.1	.0	.0		
Ft. Churchill	30	.1	.0	.0		
Ft. William	30	.1	.0	.0		
Fredericton	30	.0	.0	.0		
Goose Bay	30	.0	.0	.0		
Halifax	30	.1	.0	.0		
Inuvik	30	.1	.0	.0		
Montreal	30	.1	.0	.0		
Moosonee	25	.1	.0	.0		
Ottawa	30	.1	.0	.0		
Quebec	30	.0	.0	.0		
Regina	30	.1	.0	.0		
Resolute	30	.1	.0	.1		
St. John's, Nfld	30	.0	.0	.0		
Saskatoon	30	.1	.0	.0		
Saulte Ste Marie	30	.1	.0	.0		
Toronto	30	.1	.0	.0		
Vancouver	30	.1	.0	.0		
Whitehorse	30	.1	.0	.0		
Windsor	30	.1	.0	.0		
Winnipeg	20	.1	.0	.1		
Yellowknife	30	.1	.0	.1		
Network summary	704	0.1	0.0	0.0		

NA, no analysis reported.

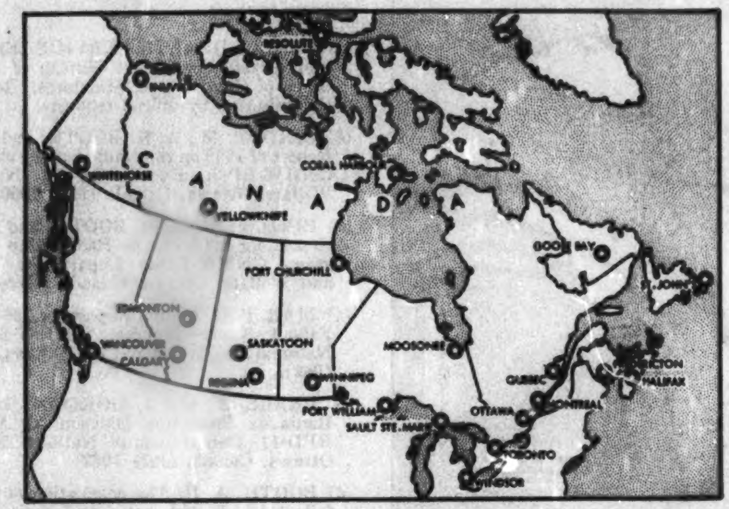
RESOLUTE
INUVIK
WHITEHORSE
C A N A D A
YELLOWKNIFE
CORAL HARBOUR
FORT CHURCHILL
GOOSE BAY
ST. JOHNS
EDMONTON
SASKATOON
VANCOUVER
CALGARY
REGINA
WINNIPEG
FORT WILLIAM
SAULT STE. MARIE
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
MONTREAL
OTTAWA
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data in the December 1968 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

4. Pan American Air Sampling Program November 1968

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling locations are shown in figure 4. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports*. The November 1968 air monitoring results from the participating countries are given in table 3.

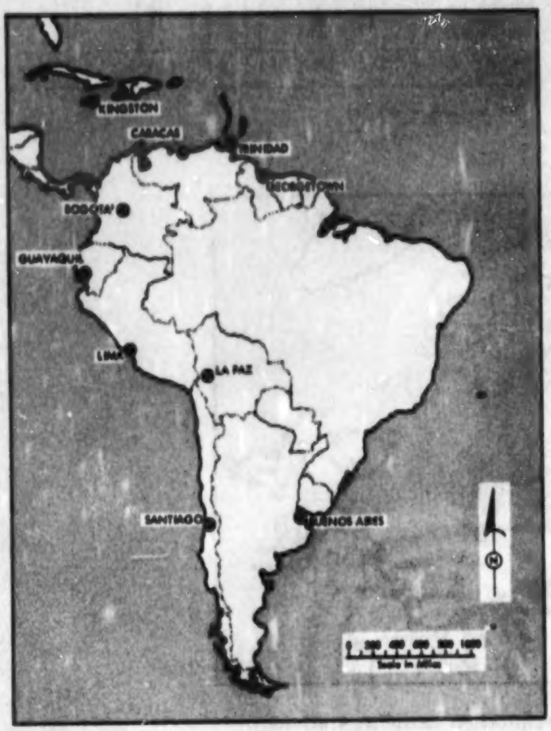

Figure 4. Pan American air sampling program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, November 1968

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average ᵃ
Argentina: Buenos Aires	6	0.39	0.26	0.32
Bolivia: La Paz	5	.42	.06	.30
Chile: Santiago	28	.53	.03	.27
Colombia: Bogota	7	.15	.01	.09
Ecuador: Guayaquil	16	.48	.11	.24
Guyana: Georgetown	7	.04	.01	.02
Jamaica: Kingston	21	.05	.01	.02
Peru: Lima	1	.41	.41	.41
Venezuela: Caracas	15	.21	.02	.07
West Indies: Trinidad	19	.14	.01	.04
Pan American summary	124	0.53	0.01	0.15

ᵃ The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

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(4) MAR, P. G. Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(5) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(6) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Offsite Surveillance for Three Events at the Nevada Test Site[1] January and March 1968

As a consequence of the U.S. Atomic Energy Commission's (AEC) underground nuclear testing program at the Nevada Test Site, three releases of low levels of radioactivity were detected offsite during the period, January through June 1968. The offsite monitoring program is conducted for the AEC under a memorandum of understanding by the Southwestern Radiological Health Laboratory of the Bureau of Radiological Health.

Project Cabriolet (*1*), a 2.5-kiloton nuclear excavation experiment conducted on January 26, 1968, as part of the Plowshare program, released a small amount of radioactivity to the environment north of the Nevada Test Site. The maximum external gamma radiation level measured during cloud passage at a populated location was 65 mR/hr. This was recorded by a permanent gamma-ray exposure rate recorder at Clark Station, Nev. A monitor using a portable survey instrument observed a maximum reading of about 48 mR/hr during cloud passage at the same location. Dosimeters used to document exposures from cloud passage plus 7 days of residual activity at Clark Station measured an integrated net exposure of 8 mR. An exposure rate of 20 mR/hr was measured at Stone Cabin Ranch near Clark Station with a portable survey instrument. Exposure rates measured at other offsite locations were over an order of magnitude less than the Stone Cabin values. A dosimeter located at Stone Cabin Ranch prior to cloud passage and collected 13 days following the experiment, showed an integrated net exposure of 8 mR. For this event, 275 milk samples from 51 stations were collected and analyzed. Forty-nine samples from 18 stations contained fresh fission products. Summaries of the peak results of air and milk sampling are shown in tables 1 and 2.

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[1] This article is presented as a contribution from the U.S. Atomic Energy Commission.

Table 1. Five highest gross beta radioactivity and associated isotopic results from air sample filters, Cabriolet event January 26, 1968

Location	Time	Gross beta radioactivity (pCi/m³)	Gross beta radioactivity $\left(\frac{\text{pCi-hrs}}{\text{m}^3}\right)$	Filterᵃ	Iodine-131		Tellurium-iodine-132		Iodine-133		Iodine-135	
					(pCi/m³)	$\left(\frac{\text{pCi-hrs}}{\text{m}^3}\right)$	(pCi/m³)	$\left(\frac{\text{pCi-hrs}}{\text{m}^3}\right)$	(pCi/m³)	$\left(\frac{\text{pCi-hrs}}{\text{m}^3}\right)$	(pCi/m³)	$\left(\frac{\text{pCi-hrs}}{\text{m}^3}\right)$
Stone Cabin Ranch, Nev.	1030 1800	33,000	160,000	PF CC	320 72	1,600 540	180 56	880 300	2,500 2,900	12,000 14,000	ND ND	ND ND
Clark Station, Nev.	0730 1030	15,000	130,000	PF CC	180 110	1,300 900	230 60	2,300 6,00	3,000 3,300	17,000 30,000	ND ND	ND ND
Warm Springs, Nev.	0900 1415	880	17,000	PF CC	2.7 .4	78 11	4.0 1.0	110 33	88 13	1,800 340	ND ND	ND ND
10 miles west Warm Springs, Nev.	1045	2,000	13,000	PF	11	73	18	120	130	780	ND	ND
Highway 6 (unpopulated)	1715			CC	6.7	44	.4	2.6	150	980	ND	ND
[illegible] Mine, Nev.ᶜ	1035 1335	3,800	7,600	PF CC	18 5.5	36 11	29 2.8	58 5.6	300 160	580 320	ND ND	ND ND

ᵃ PF—Particulate filter to collect particulate fission products.
CC—Charcoal cartridge, secondary to particulate filter, for collection of reactive gases, primarily iodine.
ᵇ January 26.
ᶜ Temporary sampler.
ND, nondetectable.

Table 2. Maximum iodine-131 radioactivity in milk samples from family milk cows following the Cabriolet event

Location	Date milked (1968)	Iodine-131 (pCi/liter)ᵃ
Mt. View Ranch, Death, Nev.	2/8	630
River Ranch, Death, Nev.	2/1	160
Cold Creek Ranch, Pancake Summit, Nev.	1/27	110
Martin Ranch, Potts, Nev.	1/28	110

ᵃ Extrapolated to date of milking.

Another Plowshare event, Project Buggy I (*2*), a cratering experiment consisting of a row of five 1.1-kiloton nuclear explosives, was conducted on March 12, 1968. A small amount of radioactivity was released to the environment north of the Nevada Test Site. Results show the highest external gamma-ray exposure rate observed in the offsite area was 8.5 mR/hr measured by a portable survey instrument during cloud passage 4 miles east of Warm Springs, Nev. The highest external gamma-ray exposure rate observed at a populated location was 1.5 mR/hr at Warm Springs. A dosimeter, which documented cloud passage plus 8 days of residual exposure at the location east of Warm Springs, showed an integrated net exposure of 11 mR. A dosimeter exposed at Warm Springs during the same period showed no exposure above background. Two hundred and ten milk samples from 48 stations

Table 3. Five highest gross beta radioactivity and associated isotopic results from air sample filters, Buggy I (March 12)

Location	Time	Gross beta radioactivity (pCi/m³)	Gross beta radioactivity $\left(\frac{\text{pCi-hrs}}{\text{m}^3}\right)$	Filterᵃ	Iodine-131		Tellurium-iodine-132		Iodine-133		Iodine-135	
					(pCi/m³)	$\left(\frac{\text{pCi-hrs}}{\text{m}^3}\right)$	(pCi/m³)	$\left(\frac{\text{pCi-hrs}}{\text{m}^3}\right)$	(pCi/m³)	$\left(\frac{\text{pCi-hrs}}{\text{m}^3}\right)$	(pCi/m³)	$\left(\frac{\text{pCi-hrs}}{\text{m}^3}\right)$
Warm Springs, Nev.	1037 1545	12,000	59,000	PF CC	75 22	380 110	120 26	610 130	610 310	3,100 1,600	1,800 2,500	9,200 13,000
Reed Ranch Nev.ᵇ (unpopulated)	1105 1305	19,000	39,000	PF CC	46 31	92 62	72 40	140 80	250 360	500 720	820 800	1,600 1,600
Eureka, Nev.	0700 1700ᶜ	3,800	38,000	PF	16	160	40	400	110	1,100	ND	ND
Blue Jay, Nev.	0705 1615	3,900	35,000	PF ᵈCC	23 20	200 100	29 25	260 130	160 300	1,400 1,500	570 1,200	5,100 6,100
Twin Springs, Nev.	0800 1525	910	6,900	PF CC	4.6 4.2	35 32	5.5 5.1	42 39	34 47	260 360	120 90	910 690

ᵃ PF—Particulate filter to collect particulate fission products.
CC—Charcoal cartridge, secondary to particulate filter, for collection of reactive gases, primarily iodine.
ᵇ Temporary sampler.
ᶜ No charcoal cartridge.
ᵈ CC added 3/12, 1110 to 1615.
ND, nondetectable.

were collected for this event. Seventy-one samples from 20 stations contained fresh fission products. Summaries of peak results from air and milk sampling are shown in tables 3 and 4.

Table 4. Maximum iodine-131 radioactivity in milk samples from family milk cows following the Buggy I event

Location	Date milked (1968)	Iodine-131 (pCi/liter)[a]
Pohlander Ranch, Wells, Nev.	3/15, 3/16	330
Circle Ranch, Pancake Summit, Nev.	3/15	100
Mt. View Ranch, Diablo, Nev.	3/16	80

[a] Extrapolated to date of milking.

The Hupmobile event, a low yield[1] underground nuclear weapons test conducted at the Nevada Test Site on January 18, 1968 (*1*), released very low levels of radioactivity to the offsite environment. The maximum portable survey instrument reading was 0.7 mR/hr at Dansby's Ranch near Lathrop Wells, Nev., and also 4 miles west of Lathrop Wells on Highway 95. Dosimeters placed at several downwind locations detected no exposures above natural background. Of the 45 milk samples collected from 16 stations, 3 stations showed fresh fission products in 4 samples. Summaries of peak results from air sampling are shown in table 5. The maximum iodine-131 radioactivity in milk samples from family milk cows was 80 pCi/liter which occurred at the Rooker Ranch, Lathrop Wells, Nev. on January 18, 1968.

Concentrations in air and milk from all three events are extrapolated to the end of air sampling period and date of milking, respectively.

The low levels of radioactivity released to the environment by these events did not exceed those safety criteria established in Chapter 0524, Standards for Radiation Protection, of the AEC Manual.

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(*2*) U.S. ATOMIC ENERGY COMMISSION. Reported nuclear detonations, March 1968. Radiol Health Data Rep 9:240 (April 1968).

Table 5. Five highest gross beta radioactivity and associated isotopic results from air sample filters Hupmobile

Location	Time	Date	Gross beta radio-activity (pCi/m³)	Gross beta radio-activity (pCi-hrs/m³)	Filter[a]	Iodine-131		Tellurium-iodine-132		Iodine-133		Iodine-135	
						(pCi/m³)	(pCi-hrs/m³)	(pCi/m³)	(pCi-hrs/m³)	(pCi/m³)	(pCi-hrs/m³)	(pCi/m³)	(pCi-hrs/m³)
Dansby's Ranch[b] Amargosa Valley, Nev.	0935	1/18	1,100	9,000	PF	[c]ND	ND	260	2,100	30	240	950	7,900
	1715	1/18			CC	ND	ND	ND	ND	53	430	630	5,100
Lathrop Wells, Nev.	0825	1/18	310	3,700	PF	ND	ND	90	1,100	12	140	270	3,200
	2010	1/18			CC	ND	ND	ND	ND	21	250	280	3,000
Death Valley Junction, Calif.	0630	1/18	210	1,900	PF	ND	ND	42	380	5.6	52	190	1,700
	1540	1/18			CC	ND	ND	ND	ND	5.1	47	180	1,700
Shoshone, Calif.	0952	1/18	8.0	190	PF	1.0	24	3.9	92	6.1	140	ND	ND
	0925	1/19			CC	ND	ND	ND	ND	ND	ND	ND	ND
Barstow, Calif.	0700	1/19	2.8	68	PF	.3	7.2	1.6	38	3.3	80	ND	ND
	0700	1/20			CC	ND	ND	ND	ND	ND	ND	ND	ND

[a] PF—Particulate filter to collect particulate fission products.
CC—Charcoal cartridge, secondary to particulate filter, for collection of reactive gases, primarily iodine.
[b] Temporary sampler.
ND, nondetectable.

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[1] Low yield is defined as 20 kilotons or less TNT equivalent.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Bettis Atomic Power Laboratory, and the SIC Prototype Reactor Facility.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

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1. Bettis Atomic Power Laboratory[2]

January–December 1967

Westinghouse Electric Corporation
Pittsburgh, Pa.

The Bettis Atomic Power Laboratory (BAPL), operated for the Atomic Energy Commission by the Westinghouse Electric Corporation, was established in 1949 to conduct research and development operations related to naval atomic propulsion systems and to the central station power reactor at Shippingport, Pa. Routine environmental monitoring data from the sampling locations shown in figure 1 show no significant contribution from laboratory operations to environmental radioactivity levels.

Gaseous radioactive waste

The release of gaseous radioactive waste is monitored by continuous air sampling to assure compliance with laboratory regulations. The stack gas limits for the laboratory are based on the 168-hour nonoccupational MPC in air as specified in AEC Manual Chapter 0524. At no time during 1967 did the concentration of stack releases exceed the required limits. The general public outside the boundary of the laboratory was not exposed to radiation above normal background levels.

Total gaseous radioactivity released to the environment during 1967 was 1.16 mCi alpha and 76 mCi beta-gamma. This compares favorably with 2.9 mCi alpha and 340 mCi beta-gamma radioactivity released during 1966.

Liquid radioactive waste

Liquid effluent discharged from the laboratory is sampled continuously. Composite samples are analyzed weekly for gross alpha and gross beta-gamma radioactivity, and quarterly for strontium-90 radioactivity.

The average concentrations of gross beta radioactivity in the main laboratory liquid effluent during 1967 was 520 pCi/liter. This was slightly lower than the average concentration of 540 pCi/liter observed for the last 6 months of 1966.

The average concentration of gross alpha radioactivity in the main laboratory effluent was 4.7 pCi/liter; a reduction from the 5.6 pCi/liter average for the July–December 1966 period.

Average radioactivity in liquid waste effluent from the critical facility operations during 1967 were: alpha radioactivity <400 pCi/liter, beta-gamma radioactivity—1.36 × 10^6 pCi/liter. Comparable values for the last 6 months in 1966 were 130 pCi/liter for alpha radioactivity and 520 pCi/liter for beta-gamma radioactivity.

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[2] Summarized from "Bettis Atomic Power Laboratory, Environmental Monitoring Report, Calendar Year 1967" (WAPD-O-(IHR)-1035).

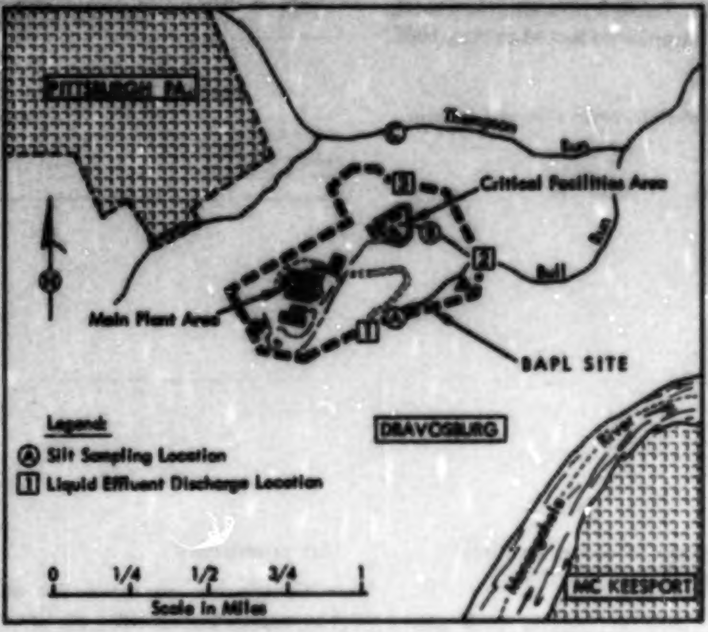
PITTSBURGH PA.
Thompson
Run
Critical Facilities Area
Bull
Run
Main Plant Area
BAPL SITE
DRAVOSBURG
Monongahela River
MC KEESPORT
Legend:
Ⓐ Silt Sampling Location
1 Liquid Effluent Discharge Location
0
1/4
1/2
3/4
1
Scale in Miles

Figure 1. Bettis Atomic Power Laboratory sampling stations

Background monitoring stations

Background beta-gamma radiation levels were continuously monitored and recorded at 34 film badge monitoring stations located at 100-yard intervals along the boundary of the laboratory property which lies within the controlled confines of the Bettis Atomic Power Laboratory site.

The average beta-gamma background radiation level during 1967 was 0.072 mR/hr for the main laboratory area and 0.046 mR/hr for the critical facility area. The respective average exposure values for July through December 1966 were 0.051 mR/hr and 0.010 mR/hr. Table 1 summarized results obtained during 1967 from the background monitoring stations.

Table 1. Beta-gamma background radiation monitoring, Bettis, 1967

Location	Exposure levels (mR/hr)	
Main laboratory area (20 locations)	Maximum	0.729
	Average	.072
Critical facility area (14 locations)	Maximum	.080
	Average	.046
All locations	Average	.062

Stream silt

Stream silt samples were collected quarterly at the three locations shown in figure 1. The results of analysis of these samples are presented in table 2. The average alpha and beta-gamma radioactivity concentrations of stream silt samples for 1967 were 4.5 pCi/g and 32 pCi/g, respectively. Although these concentrations represent an increase over those for 1966, they are consistent with or below concentrations detected in previous years.

Table 2. Radioactivity in stream silt, Bettis, 1967

Period 1967	Number of samples	Radioactivity (pCi/g)			
		Alpha		Beta-gamma	
		Range	Average	Range	Average
January–March	3	0.7–6.7	3.6	2.1–53	26
April–June	3	2.2–6.5	4.2	7.3–27	15
July–September	3	2.4–3.8	2.9	4.9–30	17
October–December	3	5.5–8.0	7.0	14. –73	53

Semiannual analyses for strontium-89 and strontium-90 were obtained for composites of quarterly silt samples. Table 3 presents the results of these analyses for samples collected during 1967.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1966	April 1967
July–December 1966	October 1967

Table 3 Strontium-89 and strontium-90 in stream silt, Bettis, 1967

Period 1967	Concentration (pCi/g of silt)	
	Strontium-89	Strontium-90
January–June	<0.08	0.74
July–December	< .08	.21

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2. S1C Prototype Reactor Facility[1] January–December 1967

Combustion Engineering, Inc.
Windsor, Conn.

The S1C Prototype Reactor Facility is a land-based nuclear submarine power plant operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, Inc. The prototype contains a pressurized water reactor power plant which is used to conduct research and development work and to train personnel in the operation of naval reactor power plants. Reactor power operations at the S1C Prototype Facility began in December 1959.

The low level radioactive waste discharged intermittently from S1C prototype operations consists mainly of water. Small quantities of airborne particulates in gaseous waste are also generated and released on occasion in the ventilation exhaust air.

Essentially, all of the radioactive waste originates from the activation of minute amounts of impurities or corrosion products in the circulating water used as a reactor coolant. All materials released to the environment are routinely monitored to assure that waste disposal operations comply with AEC regulations.

Air monitoring

Ventilation air from the submarine hull and the supporting facility at the prototype site may contain small amounts of radioactive gases or particulates. This ventilation air is discharged to the environment through an exhaust stack and is continuously monitored for radioactivity by automated counters which control the discharge of the exhaust air. When the AEC maximum permissible concentration limits are exceeded, the exhaust air is discharged through a high-efficiency filter bank or the ventilation system is completely shut down and the hull sealed. In addition, air is continuously sampled for particulates at onsite and offsite locations shown in figure 2.

Liquid radioactive waste

Drainage from all systems which are known to contain radioactive liquids were collected, processed and sampled prior to discharge to the environment to assure that discharge concentrations were within the required limits. In addition, waste effluent is sampled as it is discharged to the environment. These samples are analyzed for radioactivity and the results are retained as part of the permanent records.

The S1C prototype discharged a total of 1.2 × 10^6 gallons of radioactive liquid waste containing 11.7 millicuries of radioactivity during 1967 for an annual average discharge concentration of 2.4 nCi/liter.

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[1] Summarized from "S1C Prototype Reactor Facility Environmental Monitoring Report for 1967."

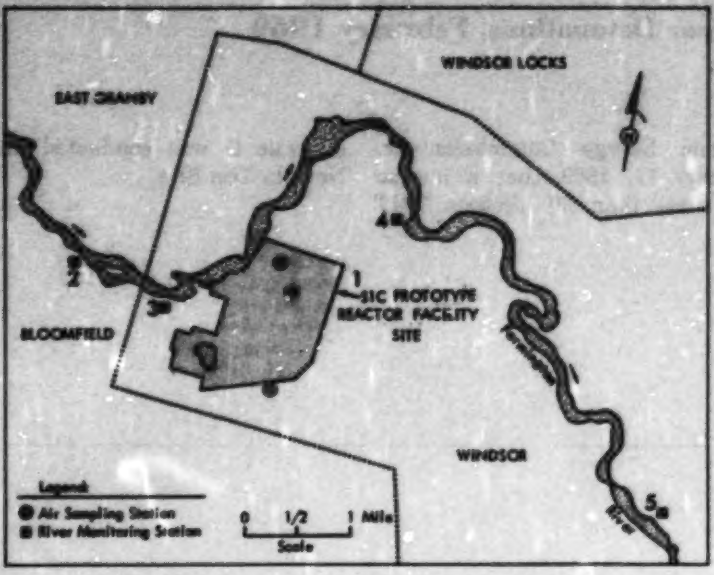

Figure 2. Environmental monitoring locations, S1C prototype site

Water monitoring

Water and sediment samples from the Farmington River are taken quarterly and analyzed. These samples are used to determine if buildup (reconcentration of radioactivity) is occurring.

The Farmington River was sampled at the outlet of the S1C Prototype discharge brook. During 1967, gross gamma radioactivity of water samples from the outlet of the S1C discharge brook ranged from 13 to 130 pCi/liter which is well below the 3.0×10^4 pCi/liter maximum permissible concentration specified by the Federal Regulations for cobalt-60, the most limiting radionuclide in S1C wastes. During 1967, the techniques used to analyze for radioactivity in water samples were changed from beta-particle to gamma-ray counting. This provides better detection of small changes in radioactivity levels.

Airborne radioactivity

All areas on site where gaseous and/or particulate airborne radioactivity could be present are directed through ducts to monitored stacks. The stacks are monitored for airborne levels on a continuous basis. The facility's operational controls ensure that the radioactive concentration in the environment does not exceed the 1,000 pCi/m^3 limit. This limit is based on levels of strontium-90 and alpha-particle emitting isotopes being insignificant.

The airborne particulate radioactivity samples taken during discharge are recounted 4 hours after discharge. The delay allows short-lived radioactivity to decay. The air effluent analysis records indicate that no significant air-borne radioactivity was discharged above natural background levels.

Conclusions

Results of the analyses and of the continuous monitoring throughout 1967 have indicated that S1C Prototype operations have met all of the Federal Regulations pertaining to radiation protection standards. Environmental analyses indicate that no significant quantities of radioactivity have accumulated above the pre-operational environmental results. It is, therefore, concluded that the facility operations have not adversely affected the surrounding environment.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1966	April 1967
July–December 1966	October 1967

Reported Nuclear Detonations, February 1969

The U.S. Atomic Energy Commission announced on February 12, 1969, that a nuclear test of low yield (less than 20 kilotons TNT equivalent) was conducted underground at its Nevada Test Site.

Errata

The data reported for the Hudson River Station at Poughkeepsie, N.Y., and the Savannah River station at Augusta, Ga., in table 1 of the article "Tritium in Surface Waters of the United States, 1966" (Radiological Health Data and Reports 9:338, July 1968) is incorrect. The correct data appears below and should be inserted in this article.

Table 1. Tritium concentration in surface waters, in the United States, 1966

Collection site	Concentration (nCi/liter)											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Hudson River: Poughkeepsie, N.Y.	<2.0	2.5±2.0	5.1±0.5	<4.1	<4.1	6	2.9±0.7	2.8±0.7	2.0±0.6	2.9±0.3	1.7±0.3	1.6±0.3
Savannah River, Augusta, Ga.	<2.0	6	6	6	6	2.2±0.6	1.4±0.6	1.5±0.6	6	1.6±0.6	3.0±0.4	2.6±0.3

In the report "Cesium-137 Concentrations in Alaskans during the Spring of 1967" by Rechen, Mikkelsen, Briscoe and Steiner, which appeared in the December 1968 issue of *Radiological Health Data and Reports*, formula (4) on page 709 is incorrect. The formula should read:

$$\frac{\text{nCi}}{\text{kg–CPM}} = \frac{0.0134}{(W)^{0.3}}$$

In the article "Plutonium in Airborne Particulates and Precipitation, July–December 1967" which also appeared in the December 1968 issue, there is an error in table 5 on page 763. The plutonium ratio should read ^{240}Pu/^{239}Pu.

In the article "Savannah River Plant, January–June 1968" which appeared in the January 1969 issue of *Radiological Health Data and Reports*, the data in table 4 on page 41 are incorrect. The corrected table appears below:

Table 4. Total fallout deposited, Savannah River Plant, January–June 1968

Radionuclide	Deposition (nCi/m²)																
	Plant perimeter locations						25-mile-radius locations										
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Alpha*	2.8	3.7	2.4	6.9	7.4	4.6	3.6	2.0	6.1	2.2	2.2	6.2	1.2	5.3	3.5	5.3	3.7
Strontium-89	.4	.1	ND	.3	.1	.2	.2	.3	.5	.3	.1	.1	.2	.2	.1	.06	.3
Strontium-90	.2	.3	.3	.3	.3	.3	.3	.3	.3	.3	.4	.4	.3	.3	.4	.4	.3
Cesium-137	.4	.7	.5	.5	.6	.6	.6	.6	.4	.5	.9	.8	.6	.6	.5	.7	.6
Cerium-141, 144	2.6	2.3	3.6	2.0	3.4	2.8	4.0	1.6	2.2	3.2	3.1	2.7	1.8	1.1	2.4	2.6	2.5
Zirconium-niobium-95	3.5	3.0	4.4	2.5	3.5	3.4	5.4	1.7	2.7	5.3	5.2	4.0	2.8	1.8	3.6	4.0	3.7
Beryllium-7	9.5	14.1	18.2	12.4	14.8	13.8	8.8	4.5	12.0	11.9	14.2	13.9	4.6	8.6	7.1	11.1	9.7
Ruthenium-106	ND	ND	.8	ND	.4	.2	1.1	ND	ND	.7	.8	ND	.7	ND	ND	ND	.3

* Multiply by 10⁻³.
ND, nondetectable, less than sensitivity of analysis.

☆ U. S. GOVERNMENT PRINTING OFFICE: 1969 O—[illegible]

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

IMPROVEMENT IN NEW YORK CITY X-RAY INSTALLATIONS DURING THE FIRST SEVEN YEARS OF A RADIATION CONTROL PROGRAM. *Hanson Blatz and Daniel E. Lynch. Radiological Health Data and Reports, Vol. 10, March 1969*, pp. 89–92.

The percentage of private medical radiographic units in New York City free from described deficiencies increased from 3 to 73 percent between 1959 and 1966; for dental radiographic units the increase was from 47 to 89 percent. The percentage of medical radiographic units considered to have adequate x-ray beam filtration increased from 75 to 95 percent in this period; for fluoroscopes the improvement was from 81 to 94 percent; and for dental machines, from 66 to 96 percent. Also, during the period the percentage of machines possessing adequate beam limitation increased as follows; for medical radiographic units, 34 to 90 percent; for fluoroscopic units, 40 to 88 percent; and for dental units, 78 to 94 percent.

KEYWORDS: Dental radiography, equipment, fluoroscopy medical radiography, New York City, radiation control, survey, x ray.